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PAPERS.

1. Contributions to the Anatomy and Systematic Arrangement of the Cestoidea. By FRANK E. BEDDARD, M.A., D.Sc., F.R.S., F.Z.S., Prosector to the Society.

XII. FURTHER OBSERVATIONS UPON THE GENUS *UROCYSTIDIUM* BEDDARD.

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(Text-figures 1-9.)

	INDEX.	Page
<i>Urocystidium</i> :		
Asexual forms		2
Sexual form		17
Summary		21

In December 1912* the Society published a communication of mine upon a tapeworm from the Musquash (*Fiber zibethicus*), of which I was able to describe both the immature and mature stages which lived side by side in the liver in cavities which are probably to be regarded as dilated portions of the liver-ducts. In May of last year I found some more examples of the same or a closely allied worm in the same situation in another specimen of the Musquash.

In this second case of infection the parasites, as in the first case, consisted of asexual and sexual examples, thus confirming my original discovery that the two generations of the worm lay side by side in the same organ of their host. The asexual

* P. Z. S. 1912, pp. 822-850.

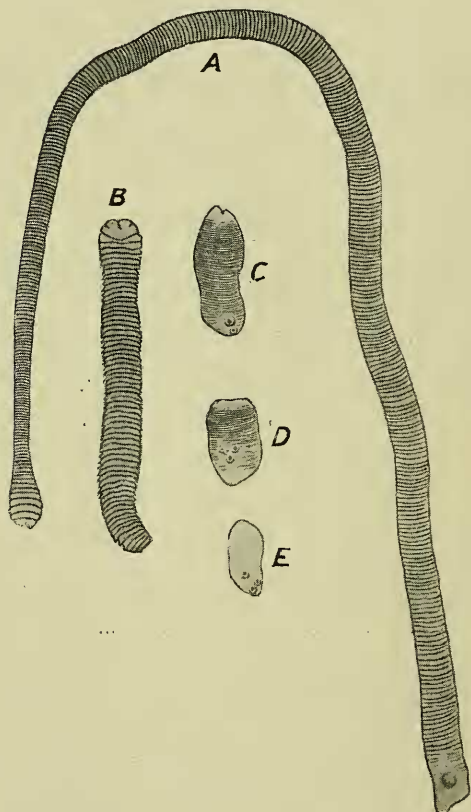


individuals were five in number, of which four are figured in text-fig. 1; the fifth was an obviously incomplete individual. I shall commence the present communication to the Society with an account of

§ *The Asexual Forms.*

The series of examples which represent the asexual phase of this *Urocystidium* showed no budding such as I originally

Text-figure 1.



- A.* Completely developed asexual stage of *Urocystidium*. *B.* Incomplete individual belonging to asexual generation. *C, D, E.* Three younger individuals of the asexual generation which represent stages in the development of the asexual form *A.*

described as the most salient and novel character in this genus. The specimens, however, which I am now about to describe, are not inconsistent with a development of this kind. That is to say,

there are no reasons for the belief that the budding which I formerly described was in any way abnormal in the species.

For it seems to me to be possible, though, as I shall point out later, by no means certain, that the three maggot-shaped worms represented in text-fig. 1 may be looked upon as newly liberated buds, perhaps being derived from the very long specimen (text-fig. 1 A) which has since ceased to produce buds. This latter specimen measured 83 mm. in length by a greatest diameter of 3.5 mm. This greatest diameter was at one end of the body; at the other end it measured only 2 mm. There were intermediate widths in different regions. Although the greater width of one end of the body suggested that this was a bladder such as I described in the original specimen, the segmentation was observed to be continuous here as elsewhere.

The same text-figure (text-fig. 1) illustrates the three younger asexual forms, which were of varying size, the largest being presumably the eldest. In any case I have found that the intermediate sized specimen is older than the smallest. The largest measured 9 mm. in length by 4 mm. in diameter. The proportions of the other two to it and to each other are correctly shown in the drawing referred to. These embryos show a segmentation least marked in the smallest example. It is a rather fine cross wrinkling; but, as I shall show in the sequel, is a true segmentation. When these embryos were living and rather transparent, they exhibited spherical spaces in the interior, visible through the outer wall, which are shown (and somewhat exaggerated) in the text-figure which has just been referred to. These cavities obviously suggest an internal budding of scolices as in *Cœnurus*, etc.; but it is not by any means clear that they are of that nature.

I examined the smallest of these three young worms by means of a complete series of transverse sections, and the middle-sized one in longitudinal sections; the structure has been compared with that of the fully grown asexual worm described in my earlier paper upon *Urocystidium*. I have, however, made some fresh sections of the fully grown asexual worm for the purposes of this comparison. The structure of the very immature maggot-like larvæ explains certain features in the structure of the fully grown asexual form which I was formerly unable to explain. I shall, however, preface these comparisons by a detailed account of

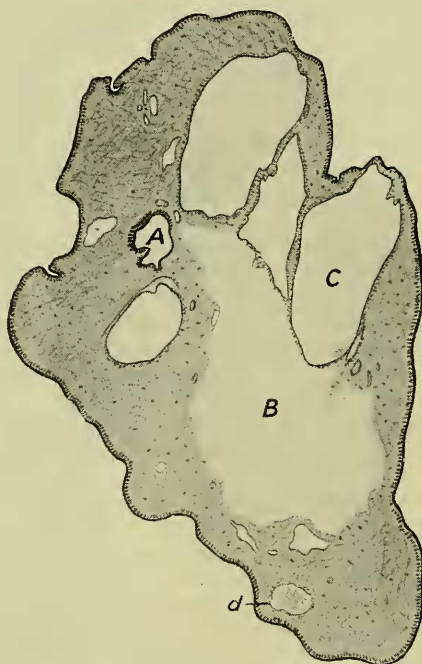
§ *The structure of the Young Plerocercoids.*

As will be seen later, the separation of these from the more advanced stage of the sexless worm is purely arbitrary. But, as there is an hiatus in point of size and general appearance, it is convenient to treat of them alone.

I use the term "Plerocercoid" in the loosest way, for an immature tapeworm which can be referred to neither the *Cysticercus* nor *Piestocystis* type. Indeed it cannot be referred with

more exactitude to the *Plerocercus* type, but perhaps on the whole is nearer to that type than to the others. The fact is that the present form and, for the matter of that, the long known *Cysticercus fasciolaris* necessitate the revision of the nomenclature of the immature Cestodes. I do not, however, propose such a step in the absence of full knowledge of the present genus, *Urocystidium*, and therefore adopt temporarily the term *Plerocercoid*. It is I think generally held that the name *Piestocystis*

Text-figure 2.



Transverse section of larva which is figured entire in text-fig. 1, *E*.

A. Cavity surrounded by gland-cells. *B.* Bladder-cavity. *C.* Third kind of cavity perhaps derivable from *A.* *d.* Tubes of water-vascular system.

should be applied to those "bladder" worms in which the cavity of the bladder is filled up to a greater depth with parenchymatous tissue, thus leaving the central cavity comparatively small and surrounded by very thick walls. On the other hand, *Piestocystis* might be converted into the *Plerocercus* type by the complete obliteration of the bladder cavity. An apparently intermediate condition is recorded by Max Braun in his account of the Cestoidea in Bronn's "Thierreich," in which (*Cysticercus*

sphaerocephalus Rudolphi) the bladder is divided up by trabeculae. *Urocystidium* is not definitely of any of these types.

Text-figure 2 represents a transverse section through about the middle region of the youngest of the two individuals which I have studied. In this region the worm is at its broadest; there is no question of a posteriorly situated bladder, as in the complete immature worm which I described and figured in my former paper. The diameter is at most 2.5–2.8 mm. The parenchyma is interrupted by numerous oval to circular and more elongated cavities which occupy the greater part of it. These cavities vary in number and size in different regions. The largest number

Text-figure 3.



Portion of a transverse section near to that represented in text-fig. 2, but more highly magnified.

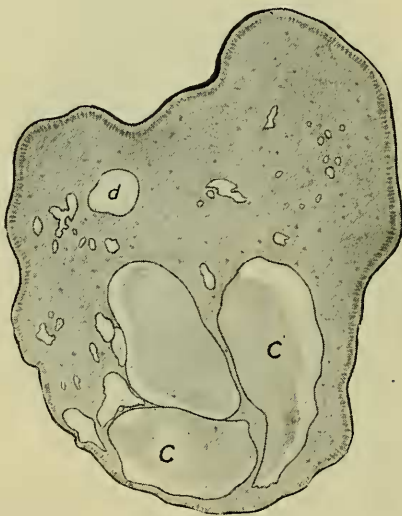
e. External surface showing cuticle and subcuticular layer. A. Cavity lined by cuticle, outside which are cells, and corresponding to cavity A in text-fig. 2.

that I have counted in a given section is 17; the smallest number—and this occurred only at the two ends of the body—is 1. I have found no direct relation between the width of the body and the number of cavities; that is to say, the cavities are more numerous at one end of the body, which measured only 2 mm. in diameter, than in the section figured, which measured nearly 3 mm.

But although there is no direct relation of this kind, it is a fact that it is only at one end of the body that the cavities are most numerous. This may possibly, for reasons which will be apparent

later, be termed the anterior end. But although there are facts which point to the view that this is the anterior end, there appears to be no difference in minute structure between the two ends of the worm. There is not even the rudimentary scolex marked chiefly by its pigmentation, which I referred to in my earlier description of the sexless form of this worm. The cavities which occupy so much of the inside of the body can be referred to four categories, and their differences are rendered clear in text-figure 2. The cavity lettered "A" is distinguished from the others by the structure of its walls. It is lined by a structureless layer (see text-fig. 3) which quite resembles the external cuticle of the worm. Round this cuticle are stalked

Text-figure 4.



Transverse section through the same larva as that represented in text-fig. 1, *E*, in a place where the cavities C only are to be seen.

d. Water-vascular tubes.

glandular cells which are quite like those of the subcuticular layer. These cells are very conspicuous, as is shown in the figure. The cavities are the expression in transverse section of tubes which are short and do not branch so far as I could discover. The obvious similarity to the external layer of the body which they show led me to expect that an opening or openings on to the exterior would be found. I have not, however, obtained perfectly satisfactory evidence of such, and indeed have found no actual orifice at all. In the case of one of these tubes, which I

followed out from beginning to end, the tube became connected at one blind extremity with the outer layer of the body by a scattered group of subcuticular cells. This as it appears to me may represent a previously existing pore. As I possess no younger example of the plerocercoid than the one described here, this point cannot be settled. Cavities having the character just described are few in number and are not always to be seen in a given series of sections. The letter B in text-fig. 2 points to a cavity of a completely different character from that which has just been described. This cavity is always single, and by following out its course there is seen to be only one of this nature in the whole body. Furthermore, it does not traverse the whole body but is restricted to the hinder end (as I have termed it), and does not nearly extend to the end which is occupied by the numerous cavities of the third character (*cf.* text-fig. 4) to be shortly described. The cavity is median in position and occupies about three-elevenths of the entire length of the worm's body. It occupies the last third of the worm but does not by any means extend to the very end. This cavity is not marked off from the surrounding solid tissues by any definite wall. On the contrary, in certain places at least the appearance is as if the tissues had gradually become broken down at the edge to form this central cavity. It fact it seems to me to be fairly certain that this is the true bladder-cavity, which agrees in most particulars with the bladder-cavity of such a form as the *Piestocystis* from the snake *Hoplocephalus superbis*, described by Prof. J. P. Hill*, concerning which that author writes †:—"The bladder-cavity in this form is represented by an irregular cavity occupying the centre of what represents the caudal bladder of ordinary *Cysticerci* and not distinctly marked off from the surrounding ground-tissue. The cavity is filled by a granular material consisting of a homogeneous matrix with granules which stain deeply with cochineal, and which represent the products of degeneration of the original central tissue." I am therefore disposed to compare and regard as equivalent these spaces in the two immature tapeworms, and to consider, as a consequence of this comparison, that the area in *Urocystidium* which is occupied by the space in question is the hinder end. There is, however, as I have already intimated, no confirmation of this view by the discovery of a scolex. The cavities lettered "C" next require attention. These cavities vary greatly in size, but are never so large as the bladder-cavity already described. They are either absent or if present necessarily peripheral where the bladder-cavity is at its largest, and often come to lie close under the subcuticular layer of the body-wall of the worm. Hence the clear spherical cavities discernible in the living worm and duly referred to above.

These cavities, however, contain no trace whatever of any

* "A Contribution to a further knowledge of the Cystic Cestodes." Proc. Linn. Soc. N.S.W. (2) ix. p. 49.

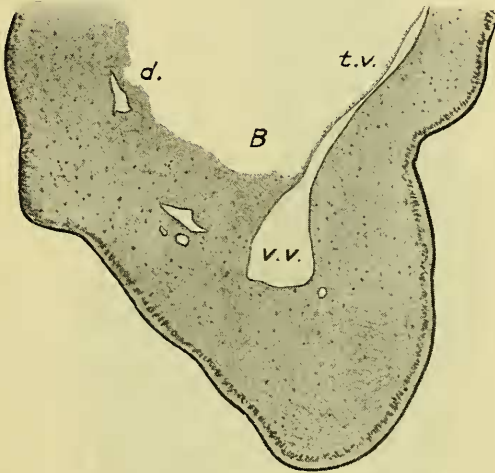
† *Ibid.* p. 52.

budding scolices. They generally appear to be empty ; but traces of an apparently coagulated fluid are to be observed after deep staining with hæmatoxylin. They have invariably well defined edges, and thus cannot be confused with the true bladder-cavity as I assume it to be. In the section which is represented in text-figure 2, these larger spaces with their well defined walls are plainly to be distinguished from the space lettered A in that figure with its lining of membrane and outer coat of glandular cells. The difference is most striking and is accompanied also by a difference in size which is apparent in the same drawing. I am not, however, convinced that there is a real difference. For some of the cavities in question show distinctly a layer of cells immediately outside of the cavity, and traces of a thin membrane within that are to be noted. An expansion of such a tube as is represented in A of text-figures 2 & 3 might well lead to such appearances by a stretching of the lining membrane and by the pulling apart of a close layer of cells. On the other hand, some of the cavities lettered C (see text-fig. 4) are undoubtedly without a distinct layer of cells around them. But here again the continued expansion and perhaps the degeneration of the cells, if they are concerned with the production of the fluid within the cavities, may have produced such a result. As I have no younger stages than that of which I am now giving the description, the matter does not as I think admit of a more definite expression of opinion. The most careful examination has not shown any connection between these cavities ; they are quite isolated as far as I could make out ; and if connections occur they cannot be abundant. Nor were there any orifices on to the exterior to be observed. I followed out through a series of sections the course of more than one of the cavities and could find no outlet from their interior in any direction. There is, however, some evidence, though not very strong, that they are formed out of the original bladder-cavity. When the latter is carefully followed up to its anterior end (as I have called it for reasons given), the cavity is seen to acquire walls like those which surround the numerous cavities lying beyond its anterior end. It ends in fact in what looks very much like one of the cavities lettered C. But this cavity does not end in the parenchyma or in connection with one or more of the rounded spaces just described. It is seen to lie within one of the latter cavities and to end in it without opening into it. But we may have here the last remaining vestige of such a connection as has been suggested. Here again the absence of younger stages forbids a more definite statement.

The last series of cavities are those lettered *d*. These are undoubtedly the tubes of the water-vascular system and are peripheral in position. It is, however, to be noted that these tubes and spaces do not invariably, though they do generally, lie outside of the cavities belonging to the category C. The water-vascular system consists partly of irregular spaces of a tubula

character, which occasionally end below and in contact with the cuticle covering the body externally. I have not, however, observed any actual pores on to the exterior. I have also found the principal longitudinal vessel, which is the ventral vessel, as I judge, of the completely developed sexless worm. I believe this to be the case, since a transverse vessel arising from it was occasionally (see text-fig. 5) quite plainly to be recognised. I could not, however, find any continuous dorsal vessel lying to the inside of this, such as is very obvious in the later stage of the plerocercoid to be described immediately.

Text-figure 5.



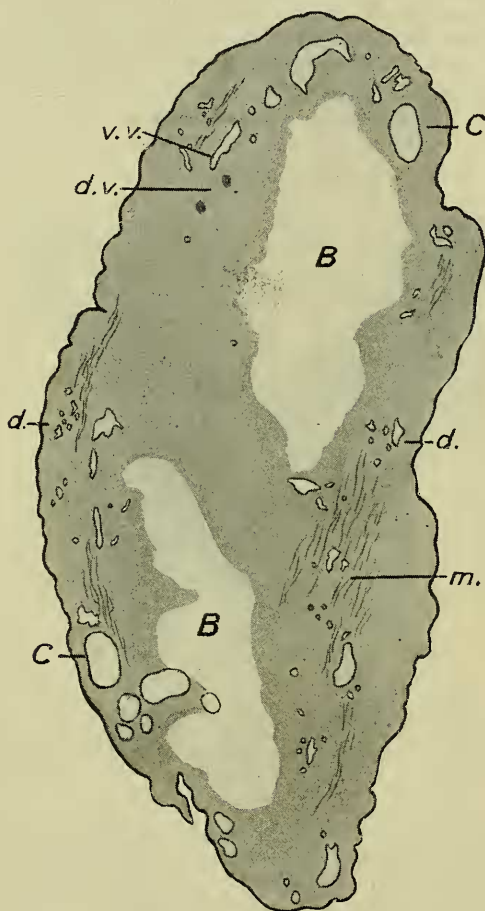
Part of a transverse section of the same individual.

B. Bladder-cavity. *d.* Water-vascular tubes. *t.v.* Transverse water-vascular tube. *v.v.* Ventral vessel.

The larger specimen, which was examined by means of longitudinal sections, showed no great differences of structure from the smaller individual. The same four systems of cavities were distinguishable and presented the same characters. The spaces *C*, as shown in the accompanying text-figure (text-fig. 6), are in form roughly spherical and hardly at all elongate. They seem to be, on the whole, actually smaller than in the younger stage, which argues commencing disappearance, or rather reduction; for, as will be seen later, these various spaces are quite recognisable in the completely developed and budding asexual worm. The bladder-cavity (*B*) seemed to me to be rather larger in proportion as well as actually than it is in the younger plerocercoid; and one would of course have expected the contrary. It is, however, not

unreasonable to suppose that there are variations in the degree of progress of the reduction of this cavity. As before, the cavities A and C are chiefly at the two ends of the worm.

Text-figure 6.



Longitudinal section through larva figured in text-fig. 1, *D*.

d.v. Dorsal water-vascular tube coiled and therefore seen cut across in several places.
m. Longitudinal muscles.

Other lettering as in text-figs. 2 & 5.

The water-vascular system (spaces lettered *d*) is more fully developed in this older plerocercoid, and it differs from that of the younger example in the presence of a perfectly distinct dorsal vessel

with very muscular walls, in addition to a much larger ventral vessel. These are shown of the correct relative size in text-fig. 6, *d.v.* & *v.v.* The branches of the ventral trunk which connect the two ventral vessels of opposite sides of the body open as I have described in the older worm, by two branches into the ventral vessel. The transverse trunk traverses the bladder-cavity and is surrounded on its transit by a layer of tissue which here, as elsewhere, shows the commencing obliteration of the bladder-cavity. In this worm the longitudinal and transverse muscular layers of the body were very evident, and the worm was much pervaded by calcareous corpuscles. The latter were often grouped a few together in sacs not far below the subcuticular layer. I shall recur to these in considering the structure of

§ *The Fully-developed Plerocercoid.*

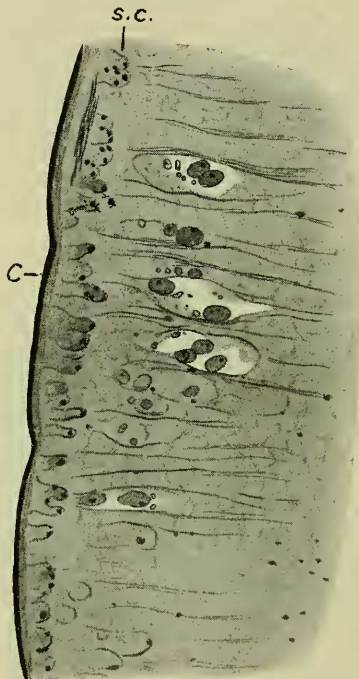
In my former paper upon *Urocystidium* I gave some account of the general structure of the sexless worm which bears the buds. I have now a few additional remarks to make upon this stage. Text-fig. 7 represents a portion of a cross section to illustrate the inclusion of groups of calcareous corpuscles in cavities below the subcuticular layer. The corpuscles contained within are both larger and smaller, and there is also some granular detritus. The cavities themselves are rather elongated, but are always separated by muscular fibres running between them and at right angles to the longitudinal axis of the worm's body. I have not studied the development of these cavities. I refer to them for two reasons. In the first place, the existence of quite similar agglomerations of calcareous corpuscles in the younger plerocercoid is one of the arguments which lead me to regard the various stages which I am now describing as being actual stages in the development of this worm—as forming a true sequence in the order which I have indicated. In the second place, these sacs of calcareous bodies are to be compared, as I believe, to apparently similar structures recently described by Prof. J. P. Hill*. The figure† given by that author agrees very closely with that appended to the present paper (text-fig. 7), and the worm with which he deals is a *Piestocystis* stage, which thus agrees with the present species in some other particulars, though, as already stated, I cannot definitely refer the asexual stage to the *Piestocystis* type. The investigation of the younger worms allows of an explanation of certain structural peculiarities in the older worm which I was unable to understand while preparing my former paper. There is, I think, no doubt that the central cavity is, as I then suspected, an extension forward of the cavity of the bladder, which we now know to be not limited to one dilated end of the body in the young of this species of tapeworm. The elongated worm-like

* "A Contribution to a further knowledge of the Cystic Cestodes," Proc. Linn. Soc. N. S. W. (2) ix. p. 60.

† *Ibid.* pl. iii. fig. 6.

asexual form is therefore in reality a bladder-worm, and not an adult in which sexual organs have not yet appeared.

Text-figure 7.



Section through skin of the fully developed asexual worm.

C. Cuticle. s.c. Subcuticular layer below which are the sacs containing calcareous corpuscles.

Furthermore, it is to my mind evident that the "closed cavities of very problematical nature" which occur in the fully-developed sexless worm, which it will be remembered are not segmentally arranged and which have a lining of cuticle and epithelial cells, are the cavities lettered A and C in my figure (text-fig. 2) of the young plerocercoids. In addition to these there are various tubular cavities which seem to belong to the water-vascular system, and which I observed to approach very closely to the exterior of the body but not to open thereon. These tubes, present in addition of course to the four longitudinal trunks, are exactly repeated in the younger stages that have been described in the present communication. There is therefore no abrupt break between the much more bladder-worm-looking embryos

and the completely formed sexless worm; the metamorphosis is obviously a matter of gradual growth. The question next arises as to what is the relation of the complete plerocercoid to the adult tapeworm. Is the one converted into the other? To settle this matter, or rather to contribute to its settlement, we must again consider the buds produced by the sexless worm.

But I shall first make a

§ *Comparison of Immature Urocystidium (fully developed Plerocercoid) with Cysticercus fasciolaris.*

In my earlier paper upon this worm I compared these two forms in certain details; but the description was concerned with external characters alone. Now that I have been able to ascertain some more facts about the development of the asexual form, a more detailed comparison will be made. My information as to *Cysticercus fasciolaris* is chiefly derived from Bartels's memoir cited below*. Although a primary difference of great importance absolutely separates the two immature forms, it is rather remarkable that the number of hooks in the *Cysticercus fasciolaris* seems to be identical with that of the sexually mature *Urocystidium*. Bartels gives 34-36 hooks, arranged, as they are in the present species, in two circles. But though this statement is made in the text, only 16 in one row are figured by him, and, moreover, in two different figures†. This is the number that is met with in the adult *Urocystidium*. In the immature form, as I have mentioned, there is no trace of hooks that I could discover. In both forms the calcareous corpuscles are very numerous. But while in the present species these corpuscles are most numerous in the sexual form, the reverse is the case in *Cysticercus fasciolaris*, the mature worm, *Tenia crassicolis*, having fewer calcareous bodies. The most noteworthy resemblance seems to me to lie in the disposition of the bladder of the two worms. In the *Cysticercus* the bladder is situated at one end of the body, and is very small compared with the free and segmented portion of the worm. As I have already pointed out, precisely the same is the case with *Urocystidium*. But in both cases the cavities found in the worm are not limited to a restricted bladder. Cavities occur in both in the segmented part; these are in *Cysticercus* mainly limited to the posterior end of the body, but they are also found anteriorly; so that there is here no essential difference from *Urocystidium*. Bartels remarks of these cavities that they are some of them connected with the bladder-cavity while others are cut off from it. He mentions that these cavities are sharply marked off from the parenchyma in which they lie, but that they cannot be said to possess definite walls. There is thus a greater resemblance to the bladder-cavity of the buds of *Urocystidium* than to that of

* Zool. Jahrb. Bd. xxi. 1902, Abth. f. Anat. p. 511.

† Loc. cit. taf. 39. fig. 21 & taf. 38. fig. 15.

the developing asexual worm which arises, as I suppose, directly from the egg. There is, however, clearly a general resemblance to the latter, and, as I think, an important resemblance.

The cavities also contain in both the immature Cestodes now under consideration a coagulable fluid apparent on staining. The tubes of the water-vascular system are much alike in the two worms. In both the dorsal vessel is the smaller and has a thick muscular wall; while the two worms also show resemblance in the fact that the transverse vessels which run across the segments arise by two origins from the larger ventral vessel. This detailed likeness is very striking. In spite of these points of likeness there are numerous points of difference between the two species. *Cysticercus fasciolaris* would seem to show no such specialisation of the bladder-cavities, or at any rate no such variation of structure in the cavities found in its interior, as does *Urocystidium*. The total absence of hooks, and indeed of a well-marked scolex, in *Urocystidium* has been already commented upon. The *Cysticercus* under consideration agrees with other *Cysticerci* in differing absolutely from *Urocystidium* in these features. Dr. Bartels heads one section* of his memoir upon *Cysticercus fasciolaris* as follows:—"In welcher Beziehung stehen *Cysticercus fasciolaris* und *Tænia crassicollis* zu einander betreffs der Höhe ihrer Organisation?" The same query might well be asked concerning *Urocystidium*. In the former case the only differences are in the disappearance of the traces of the bladder, the appearance of the gonads, and, apparently, the slight increase of the number of hooks upon the scolex. The general level of organisation is upon precisely the same level in the two stages of development. The latter statement can well be made of *Urocystidium*. Transverse sections of the sexual adult and the completely developed immature stage, which are shown in my earlier paper upon this worm, leave little structural difference between the two forms save the two features in which the *Cysticercus* differs from its *Tænia*. The only important addition to be made is of course the absence of a scolex in the young *Urocystidium*. It was, in fact, not merely the equality of organisation but also the details of likeness which led me to assume originally that the one form of *Urocystidium* was really a stage in the development of the other. So far as is known, these two forms are the only ones among the higher Cestodes in which there is a high grade of organisation in the sexless stage. And it is perhaps this general fact of likeness which tends to impress upon one the further points of likeness between this form and *Cysticercus fasciolaris*, and to diminish the really important points of difference already referred to. As to further development, Bartels is of opinion that the *Cysticercus* develops into the *Tænia* with no further change than the loss of the bladder.

* *Loc. cit.* p. 542.

§ *Comparison of the Young Plerocercoids with the Buds.*

As has been already observed, there are no free living stages of this worm in my possession which are younger than the specimens described in the foregoing section. But it has also been suggested as a possibility that the buds formerly described by me may be a stage antecedent to those which I have termed the young plerocercoid. When freed from the fully developed asexual worm they may drop off into the liver ducts and there increase in size—principally in breadth, for the length of the longest buds is not far removed from that of the smallest free plerocercoid—and, after a certain alteration in structure, show the characters of the maggot-like larvæ which have been dealt with in detail in the last few pages. I do not think, however, that this can be the case, failing at any rate further evidence. For the most “mature” of the buds which I studied in some detail for my earlier communication upon this genus has a much more “adult” structure than has the youngest of the plerocercoids described in the present paper. And if we are to assume that the young plerocercoids described here develop gradually into the large sexless worm, as I think is fairly certain, this possibility is rendered still less likely.

I shall now indicate the differences in structure between the plerocercoids and the buds which oppose themselves to this comparison. The various stages in the development of the buds shown in text-fig. 116 * of my earlier paper seem to show that the bladder is the first part of the worm to appear and that the vermiform region is an outgrowth of this. For the buds are at first bladder-like outgrowths of the stock, and then develop a process at the free end which gets to be more important. Now in the plerocercoids the whole worm is at first also little more than the bladder region; but this is converted into the more mature individual by a proportionate suppression of the cavities which together constitute the bladder-like region, and the gradual conversion of the greater part of the worm into a more markedly vermiform body. Traces of the bladder-cavities, however, persist in the latter up to the anterior end. This difference of mode of growth does not, however, exhaust the differences observable between the two series of young worms. The bladder-cavity itself differs in the two. As already described, it has no proper walls in the free young plerocercoids, while in the buds it has not precisely a definite wall, but the inner layer is thickened and it is sharply marked off from the empty space which it encloses: it is, in fact, like some of the cavities lettered C in the young free worms.

There is, however, the tube which I have lettered α in my figure of a transverse section through a bud †, which is in structure very like the spaces lettered A in the transverse section through the young plerocercoid (text-figs. 2, 3). The former is,

* P. Z. S. 1912, p. 824.

† *Ibid.* text-fig. 116, p. 833.

however, distinctly tubular and definitely opens on to the exterior, in both of which characters it differs from the cavities described above in the young free larva. The water-vascular system presents both similarities and dissimilarities in the two. In the bud there are but two longitudinal vessels, one on each side of the body. These are connected by transverse vessels and are thus in all probability to be looked upon as ventral vessels; the dorsal, it is to be presumed, appear later. The youngest free larva also possesses only two lateral longitudinal trunks, which are for similar reasons to be regarded as ventral vessels; but it has in addition other water-vascular tubes which are completely wanting in the bud. In fact, there are no detailed resemblances such as would be sufficient to overbalance the general unlikeness between the buds and the free living asexual parasite; they do not appear to me to be stages in the same series.

§ *Origin of the Sexual Form.*

It seems to me to be much easier to believe, on the other hand, that the buds are a stage in the development of the sexual worm. But here it is only a matter of possibility or probability; there are but few facts. And these facts are mainly negative. For there are actually no more positive points of likeness between the bud and the sexual form than there are between the buds and the fully developed sexless form; but perhaps the resemblances, though few, are of a little more importance. In the first place, the solidity of the body anteriorly to the bladder, save for the one tube which runs along it, is more suggestive of the adult sexual worm, than of the sexless worm with its abundant cavities and continuous bladder-cavity. The gradual tapering off of the single cell-lined cavity, which the buds possess, as it approaches the anterior end of the body, indicates the ease with which it may vanish altogether. In the second place, the bud shows no series of peripheral tubes which I have regarded, in the case of the young free worms, as a part of the water-vascular system. These are absent from the sexually mature worm. Finally, there are the aggregations of cells, of which I have spoken in my first paper upon this worm and which may be the commencing sexual organs.

This is the most important resemblance. The other features in the structure of the bud do not forbid the view which I am now supporting by such facts as are available. But they might with equal reason be urged in favour of a likeness with the free sexless stage.

There is obviously nothing decisive about the retardation in the appearance of the smaller dorsal water-vascular tube, and the fact that there are two layers of bundles of longitudinal muscular fibres in the cortex points with equal directness to the adult worm and to the complete immature worm. But the comparison here is with the *fully developed* immature tapeworm, and not with the maggot-

like earlier stages of this (if I am right in so regarding them). It would appear, therefore, that the facts which have just been referred to in the structure of the bud may be perhaps really looked upon as arguments in favour of a comparison of the bud with the fully adult sexual form and a conclusion that the former ultimately gives rise to the latter. For if we are to assume that these buds give rise to the plerocercoid, it will have to be further assumed that the regularly arranged and perfectly differentiated cortex and medulla of the bud becomes lost, only to be reconstructed later when the plerocercoid has arrived at the completion of its development. Of the alternatives, this seems to me to be the less likely. In short, I am obliged to admit that the development of the bud into the sexual worm is mainly probable on account of the difficulties which beset the view that it is an earlier stage of the plerocercoid.

§ *The Sexual Form.*

The sexual form appears to differ in several particulars from that of my first specimen of *Urocystidium gemmiparum**, and I have been able to compare the two placed side by side. It is to be noted, however, that they agree with each other in differing from the asexual worms in their browner colour. This is perhaps rather more strongly marked in the individual which forms the subject of the present communication to the Society.

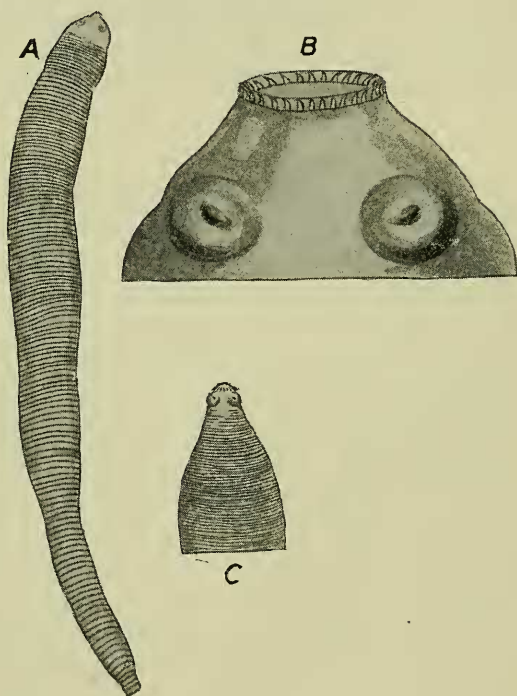
In the case of both worms, the segmentation begins immediately after the scolex and the segments are quite narrow. They get, however, slightly longer at the posterior end of the body, and in the new specimen the last three segments are comparatively long though not nearly so long as broad. The body ended abruptly with the last of these segments. The present worm contrasts with the original specimen in its smaller size; it is of about half the length, measuring some 42 mm., and is not nearly so broad, the greatest breadth being 4 mm.

It is, however, in the scolex that the most prominent difference between the two individuals is to be found. Of this region I have had drawings prepared, which are shown in text-figure 8. On a superficial view, with a hand-lens only, the scolex of the second individual is seen to be much smaller than that of the specimen which I described a year ago. This difference is heightened when the two are compared under a compound microscope. The upper right-hand figure in the illustration (text-fig. 8 C) shows that in the new specimen the scolex end is terminated by a thin collar, in which a row of setæ are imbedded forming a complete circle. A good way below this are the suckers, which are relatively small and separated from the hooks by a larger interval than that which occurs in the type example of *Urocystidium gemmiparum*. It might perhaps be held that

* *Loc. cit.* p. 841.

the differences between the two examples is due to the different state of retraction of the rostellum in both. It might be said that if we retract the rostellum of the type specimen, a collar might be formed such as is shown in the second example surrounding the depressed rostellum in which the hooks appear. While this is quite possible theoretically, it may be pointed out that the difference in size seems at first sight and without microscopic investigation too great to allow of such a comparison. This

Text-figure 8.



A. Sexual individual. B. Scolex of same with rostellum retracted.
C. Anterior end of sexual individual described in P. Z. S. 1912, p. 841.

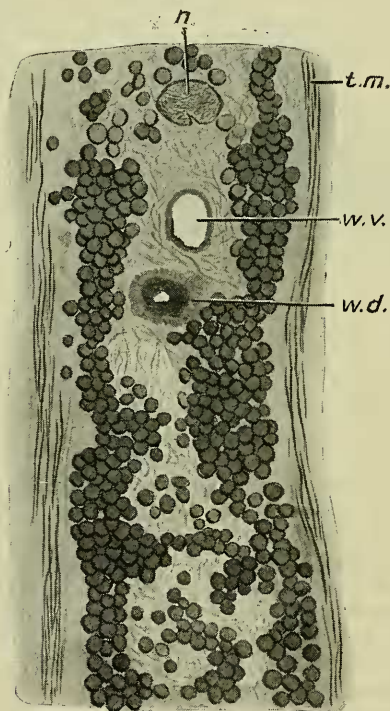
will readily be seen on an inspection of text-fig. 8, A & B, which are drawn of the correct relative size. It may also well be that the thin collar-like edge which bears the hooks in the fresh example of *Urocystidium* is a permanent structure, and that there is nothing to compare with it in the earlier example. But this point cannot of course be settled in the absence of other specimens. On the whole it would seem impossible that any differences in

the state of contraction of the two examples could account for the plain lack of resemblance shown in the various figures referred to. Moreover, the suckers are very much smaller in the new example of *Urocystidium*, and by no means so prominent as are those of *Urocystidium gemmiparum*. So much then for the scolex of this worm, so far as it can be seen by a mere inspection of the uninjured worm. I have made a series of transverse sections through the scolex after the above figures were drawn, in order to elucidate further the structure of this part of the body. In spite of the apparent differences enumerated above, I cannot find any reason after a microscopic examination for regarding this individual as referable to a second species of the genus. The hooks are disposed in two rows, the hooks of each row alternating; there are sixteen to each row and those of one row are much smaller. The apparently smaller size of the suckers is due to their complete retraction. It is very important to note how individuals may appear to differ if not examined microscopically and when in a different state of contraction.

In my original description of *Urocystidium gemmiparum* I gave a somewhat detailed account of what I then supposed to be ripe ova scattered thickly through the segments of the body, particularly towards the end of the body. I have re-examined the original sections which I made, and have cut fresh sections from the original material in order to consider the matter afresh. A part of one of these sections is illustrated in text-fig. 9. It will be seen that, as I have already reported, the medulla as well as the cortical layers is stuffed with bodies closely resembling eggs. They are large and lie loosely in the parenchyma, being often aggregated into clumps. This section was regarded by two naturalists, to whom I showed it, as being chiefly made up by these masses of what appear to be eggs. I confirm my original description as regards the structure of these bodies. They consist of a nucleated cell closely surrounded by a transparent homogeneous layer, which I noted as being the egg-shell. I did not see the nucleus in all of the supposed eggs, which I carefully examined with high powers. This matter I am able to correct by the subsequent observations upon which I report here. The nucleus is present in all of them; but often it is seen in various stages of degeneration, culminating in freedom from granules, and thus almost complete transparency. In the second example of this tapeworm, the same cells were present and no particular description of them is necessary. The occurrence of the same bodies in a second individual led me to suspect that they were not eggs; for on the hypothesis of a diceious tapeworm it might be expected that a male would be found. I had realised the likeness of these bodies to calcareous corpuscles, but had abandoned that view in deference to their immense multitude, and if anything greater prevalence of numbers in the medullary part of the body of the worm. Moreover, it is usually stated that the nucleus of the cell in which lime is deposited, and which becomes in consequence a

calcareous corpuscle, is excentric. This is pointed out by Benham* and in the investigations of v. Janicki upon the development of these bodies in the genus *Davainea*†. On the other hand, it is to be admitted that Lönnberg‡ found the nuclei to be often centric as well as excentric in the Bothriocephalid *Abothrium rugosum*. There are, however, two strong arguments in favour of regarding these bodies as calcareous bodies: these are, first, that they bubble with gas on being treated with dilute hydrochloric acid; and, secondly, that I have found in this second example of the worm rudiments of the real generative organs.

Text-figure 9.



Part of a transverse section through sexual form of *Urocystidium gemmiparum*.

n. Nerve-cord. *t.m.* Transverse muscles. *w.d.* Dorsal water-vascular tube.
w.v. Ventral ditto. The medulla is crowded with darkly stained calcareous bodies.

The second argument is I think conclusive as against the view that the bodies in question are eggs. The reproductive organs

* 'A Treatise on Zoology,' Oxford, pt. iv. p. 107 (1901).

† Arch. de Paras. t. vi. 1902, p. 261.

‡ K. Svensk. Vet.-Ak. Handl. Bd. 24, 1891, p. 78, pl. i. fig. 5.

are in all the segments which I examined quite immature; but the cord of cells representing the future ducts were quite visible and were seen to lie always on the same side. This worm therefore appears to have unilateral generative pores. This discovery renders the novelty of this worm as a genus rather more doubtful. But the facts now known do not permit of a settlement of the question. For the structure of the reproductive organs can alone, at the present day, determine the systematic position of these tapeworms. It is, as I think, unsafe to base generic identity upon other characters in the absence of information about the reproductive system. But it may be pointed out that there are undoubtedly certain resemblances in the structure of the water-vascular tubes of this worm and of *Tenia crassicollis*, which are mentioned above* in comparing the young of the two worms. But I do not think generic identity with *Tenia* proved.

§ Summary and General Considerations.

The fresh material reported upon in the foregoing pages enables me to define more fully the structure and life-history of the tapeworm which I described formerly as *Urocystidium gemmiparum* †, from *Fiber zibethicus*.

As for the general structure of the fully grown asexual generation I have nothing to add to my former description, to which reference may be made. The individual, however, which I have described and figured in the present paper, differs from that previously described in showing no development of buds. Two earlier stages in the development of the asexual worm are described in the present paper. These are plump, short, but still vermiform, and segmented, worms. They differ from the full-grown asexual worm in the greater proportionate size of the bladder-cavity and other cavities perhaps connected with the bladder-cavity. But all of these cavities persist in the full-grown asexual stage. They show no hooks or recognisable scolex. In the earliest stage there is no differentiation of the body-wall into cortex and medulla; in the more advanced young there are but feeble traces of this differentiation, quite achieved in the completely formed asexual worm.

The structure of the asexual worm as elucidated by the younger stages described in the present paper, shows that it is not referable exactly to any type of asexual tapeworm as yet described. In spite, however, of its external and internal (transverse water-vascular vessels) segmentation, it is essentially a bladder-worm, but, as it appears, without a scolex. In complication of structure and in details, this asexual stage is not far different from the sexual stage. The sexual worm, which occurs in the same cavities of the liver side by side with

* *Supra*, p. 14.

† It is to be borne in mind as possible, but not at all probable, that the two sets of worms are of different species.

the asexual stages, is of roughly the same size as the fully-developed asexual stage. It has a very strongly muscular rostellum and two rows of sixteen hooks each, the outer row consisting of smaller sized hooks than the inner. The body of the sexual worm is crammed with large oval calcareous bodies with a centrally placed nucleus. Such bodies are also very abundant, but not so abundant, in the bladder-worms. The gonads, etc. (quite immature in both individuals) are fairly central in the proglottids, and the ducts are all directed towards the same side of the body.

It would appear, therefore, that both the structure of the immature tapeworm and the series of stages by which maturity is arrived at, are quite unlike anything that is at present known among the Cestoidea. But as there are obvious lacunæ in the information which has been set forth in the present paper, some uncertainty attaches to the life-history the course of which is suggested by those facts. There are, as it would appear, two larval stages following each other and derived from each other directly. From the egg (as I presume in the absence of earlier stages) arises the larva which I have described as a plerocercoid; this gives rise by budding to many larvæ which differ in several structural features from the asexual parent; these (and here there are no positive facts but only inference) give rise to the sexual worm. There are thus three stages in the life-history of this tapeworm which are not met with in other Cyclophyllidea, except as mere multiplication as in *Echinococcus*. *Bothriocephalus* has three distinct stages, but they are not comparable to those described here, since the first is a free-swimming ciliated larva. The complication of the life-history in this form is suggestive, of course, of the Trematoda; but I can make no detailed comparison.

2. Observations made to ascertain whether any Relation subsists between the Seasonal Assumption of the "Eclipse" Plumage in the Mallard (*Anas boscas*) and the functions of the Testicle *. By C. G. SELIGMANN, F.Z.S., and S. G. SHATTOCK.

[Received December 20, 1913 : Read February 17, 1914.]

(Text-figures 1-6.)

INDEX.

Physiology and Variation.

The observations herein set forth were made with the object of ascertaining whether any relation exists between the condition of the testicle and the seasonal assumption of the eclipse plumage in the male of the Wild Duck or Mallard (*Anas boscas*). Although the seasonal changes are well known and were fully described many years ago by Waterton, with whom the term "eclipse" originated †, it does not appear that any observations have been made on the condition of the testes accompanying the change.

What we wished to determine was, whether the assumption of the male plumage corresponded with the advent of spermatogenesis, and whether the occurrence of the "eclipse" is associated with retrogressive changes in the sexual gland.

We may point out that the interest attaching to this question is increased if the pairing habits of the wild duck and some other common birds be considered. The cockerel of the common fowl, for example, is sexually potent as soon as its external characters are declared (so that poultry breeders are careful to separate the cockerels from the pullets as soon as the former begin to show male plumage), but in the pheasant, although full male plumage is assumed in the autumn, no pairing (or any manifestation of the sexual instinct) takes place until the spring. In the wild duck the birds pair in the autumn or early winter, after the male assumes full plumage, but copulation does not occur until the spring is advanced.

Our observations fall into two series :—

1. Simultaneous observations on the plumage and the condition of the testes in a series of Wild Ducks throughout the year.
2. Observations on Wild Ducks from which the testicles have been removed.

* The expenses connected with this work were defrayed by a grant from the Royal Society, London.

† W. Yarrell, 'History of British Birds,' vol. iii. p. 175.

I.

Observations on the plumage and the condition of the Testes.

These were made on domesticated wild ducks such as are found in the London parks and supplied from game-farms. These birds are commonly slightly larger than those really wild, but they pass through the seasonal changes of plumage in approximately the same period, and appear to vary in the time (season) of their change no more than do wild birds from England and Scotland respectively. We were able to examine a few really wild birds caught in decoys in January and February, and found no substantial difference in the condition of their testes and that of those domesticated, but we did not extend these observations, since it appeared probable that the confinement of such birds might lead to abnormalities in the onset of their plumage changes, and even affect the condition of their reproductive glands.

Before dealing with the changes in the plumage and in the sexual glands of adult birds, it will be well briefly to summarize the conditions found in young or immature birds, by which we mean birds of the year, that have not yet assumed full plumage. So defined, the period covers the first five to six months of the bird's life and ends in November or December. In the young birds the nestling plumage persists until at least the middle of September, about which time a few speckled feathers appear on the legs and shoulders, the breast and belly being still unchanged. By this time the full complement of flight-feathers has appeared, but the feathers themselves are usually not more than half grown. The testes of such birds are usually quite small, measuring on an average about 10 mm. in length and about 2 mm. in breadth; they are firm on section, and yellowish brown in colour. Under the microscope the tubuli are found to be small, and with a relatively narrow lumen lined with a single layer of cells, between which certain larger spheroidal spermatogonia are intercalated. In some the cells are two deep. The interstitial stroma is very cellular, and, contrasted with the condition found in the fully functional gland, it appears relatively abundant*. There is a good deal of individual variation in the external appearance of the birds at this time, even a few days making a considerable difference. The growth of the birds and the development of the plumage proceed rapidly during October, so that by November the drakes have attained their full size, and have assumed their perfect plumage. The testes become larger and yellowish white

* We may refer here to the appearance presented by the testes of a freshly-caught wild Mallard killed during the last quarter of December. This bird weighed 1 lb. 14 $\frac{3}{4}$ ozs.; its testes, which were firm, yellowish in colour, and dry on section, together weighed 88 mg. Microscopic sections showed the tubuli to be of small size, with narrow lumen, lined with a single or double row of cells, and with larger spermatogonia occasionally occurring between the basal cells. There was no sign of spermatogenesis.

in colour, as well as softer, but no juice exudes on section, and spermatozoa are absent. At this time of the year, *i. e.* at the end of November and December, there is no marked and constant difference between the testes of the young birds of the year that have but just assumed their winter plumage for the first time, and the testes of older birds that are passing into their full plumage for the second or third time. But since our observations lead us to think that the changes in the testes may take place rather more rapidly and regularly, and perhaps a little earlier, in the older birds, we confined our observations to birds which had passed through at least one full change of plumage.

In order to make clear the significance of the plumage-changes in normal and in partially castrated adult birds, recorded below, we may give a summary of those which naturally occur in the male wild duck.

Normally in the adult Mallard (*Anas boscas*), which, it is assumed, has bred early in the spring, the curly tail-feathers are lost, and the moult of the body-feathers begins late in May or early in June. By the beginning of July the assumption of the dusky, summer, or "eclipse" plumage should be tolerably complete, though the moult of the flight-feathers has not, as a rule, begun, these being lost usually by the middle of the month. The eclipse plumage persists throughout August, during which month the Mallard, the Duck, and the young are externally very much alike. By the middle of September the curly feathers have usually appeared in the tail of the Mallard, and the bird passes from its summer to its winter plumage, which does not, however, reach its full beauty until about midwinter.

The period of the year at which the plumage changes take place varies with the latitude. In the British Museum (Natural History) there is the skin of a bird in full male plumage with curl feathers in the tail, which was killed at Shanghai (lat. 31° N.) on August 28th, 1884. The skin of another bird, killed on December 11th, 1879, at Nagasaki (lat. 33° N.), is in partial eclipse, with many brown feathers on the vertex, and eclipse feathers in the breast; while the skin of a third bird, from Wuhu, on the Yangtze, killed in January 1885, has similar, but less well marked, remains of the eclipse plumage on the breast and head.

A Table showing the condition of Plumage and that of the Testicles at each month of the year.

January 30th. Full winter plumage.

Weight of both testes, 3850 mg.: each gland is about 23 mm. in greatest length, of a yellowish-white colour and soft; fluid can be scraped from the cut surface, but it does not ooze naturally.

(In a bird killed January 23rd, the testicular tubuli were small; with well-defined lumen; cells about two deep; no spermatogenesis.)

February 14th. Full winter plumage.

Testes soft, 15 mm. in length. Tubuli large and full of well-conditioned cells, but there are no spermatozoa or spermatids. Small groups of finely granular interstitial cells are present.

February 14th. Full winter plumage.

Each gland is about 15 mm. long by 9 mm. in breadth, the tubuli are full of cells but contain no spermatozoa.

March 7th. Full winter plumage.

Weight of both testes together, 5800 mg. Testes equal in size, bean-shaped, maximum diameter 25 mm. Tubuli thickly lined with cells; a moderate number of spermatozoa in some tubuli, *i. e.* spermatogenesis is in progress.

March 16th. Full winter plumage.

Weight of testes 9150 mg. Tubules of full size, occupied by dense masses of cells; centrally there are numerous spermatozoa.

(The testes of another bird, killed on the same day, together weighed 10,170 mg.)

March 22nd. Full winter plumage.

Testes together weighed 32,500 mg. Each was as large as a pigeon's egg. Tubules of full size; typical picture of active spermatogenesis.

April 20th. Full winter plumage.

Testes large, about 50 mm. long; and so soft as to be almost diffuent on section: total weight, 30,140 mg. Spermatogenesis in active progress.

May 7th. Full winter plumage.

Total weight of testes, 30,580 mg. Macroscopically and microscopically they resemble those of the bird killed on April 20th.

May 30th. Full winter plumage.

Testes size of a haricot bean; the tubuli are distended with cells, and contain large numbers of spermatozoa. The organ is, however, retrograding, as appears from the absence of spermatid sheaves, and the fact that the spermatozoa in the centre of the tubules are badly stained.

May 30th. Full winter plumage.

Each testis, not larger than a small haricot bean, about 11 mm. long and 7 mm. broad. Tubuli, not of full size; there is a central area of vacuolated substance in which there are somewhat thinly scattered cells. No mitoses and no spermatogenesis; the whole appearance is one of inactivity.

June 6th. Full winter plumage.

Testes narrow and firm, about 13 mm. long by 4 mm. broad. Tubuli of somewhat small size, each with a peripheral layer of cells; the centre of the tubuli occupied by a vacuolated material in which cells are thinly scattered. There are no spermatozoa, but very fine deeply stained granules of chromatin occur in moderate numbers in the centre of the material (chromatolysis).

July 4th. Bird in almost full eclipse.

Testes oval, about 6 mm. in transverse diameter, pale yellow in colour, and firm on section. Tubuli small with well-defined lumen. Cells for the most part two deep. No spermatogenesis.

July 8th. Full eclipse.

Testes small, scarcely 10 mm. long by 5 mm. broad. Tubuli of comparatively small size, furnished with well-developed lumen. Cells two and three deep. No spermatozoa.

July 12th. Full eclipse.

Testes about 20 mm. long by 12 mm. broad; weight of each gland about 3700 mg. Tubuli of fairly large size, no lumen. Cells in the centre of the tubuli are small. Here and there the sheaf arrangement of spermatids is indicated, but the nuclei are mostly badly stained. No properly stained spermatozoa.

July 12th. Full eclipse.

Testes resemble those of preceding; no spermatozoa to be seen. Weight of testes together, 6560 mg.

August 17th. Full eclipse.

Testes small, diameter of transverse section 4 mm. Tubuli small, stroma relatively large in amount. Tubuli furnished with well-defined lumen, cells about two deep. No spermatogenesis.

August 21st. Eclipse.

Testes small, about 5 mm. in transverse diameter. Tubuli narrow, quite inactive. A single layer of peripheral cells; a narrow lumen; no trace of spermatozoa.

September 14th. Eclipse passing off.

Testes about 7 mm. in transverse section; weight 195 mg. Tubuli of small size, with a narrow central lumen lined with one or two layers of cells; no signs of spermatogenesis.

(In a bird killed September 13th, the testes were 6 mm. in transverse diameter; the tubuli of fair size, and filled with loosely aggregated cells; no spermatogenesis.)

September 30th. Eclipse passing off.

Many young feathers of winter plumage coming through on breast and abdomen.

Testes small, firm, somewhat brown, about 12 mm. long and 3 mm. broad. Tubuli of medium size, with central lumen; lined with cells averaging two deep.

September 30th. Full winter plumage.

Testes small, firm and somewhat brown, about 12 mm. long, but scarcely 3 mm. broad. The tubuli are of medium size only, and are filled with cells.

October 9th. Full winter plumage.

Tubuli of medium size and filled with cells. Spermatogenesis is not in progress, but amidst the central cells there appear here and there a few rod-

like bodies, apparently obsolete spermatozoa, possibly the residues of a previous state of activity.

October 25th. Full winter plumage.

Testes 15 mm. in chief diameter. Tubuli of medium size; furnished with a layer of basal cells, central to which lies a mass of cells filling the lumen of the tube. No spermatogenesis.

October 27th. Full winter plumage.

Testes about 15 mm. in longer diameter. Tubuli small, a narrow lumen in most. Cells averaging two deep. No spermatogenesis.

November 1st. Full winter plumage.

Testes 12 mm. in longer diameter. Tubuli narrow, with fine lumen. No spermatogenesis.

November 7th. Full winter plumage.

Testes about the size of a haricot. Tubuli of medium size; full of cells; no lumen; no spermatogenesis; some mitoses in the more central cells.

November 17th. Full winter plumage.

The testes fairly firm, exuding no fluid on section; together they weighed 520 mg. Tubuli of medium size; full of cells; no lumen; no spermatogenesis.

November 28th. Full winter plumage.

Testes yellowish; exuded no juice on section; weighed together 720 mg. No spermatozoa. Tubuli small, well-defined lumen. Cells average two deep.

December 6th. Full winter plumage.

Both testes of medium size, and showing active mitosis.

From the foregoing table, which details the condition of the testes in a series of birds examined throughout the year, and the state of their plumage, the following summary may be made:—

The testes attain their maximum size during the breeding-season, *i. e.* at the end of March or beginning of April. At this time each gland is almost as large as a pigeon's egg, and so soft as to be nearly diffuent on section, while the juice which exudes contains enormous numbers of spermatozoa. Although this condition is more or less maintained during the first half of May, by the end of that month the glands present a very different appearance. *Although the birds are still in full winter plumage, the testes have shrunk to the size of a haricot bean*; no mitotic figures are encountered in the cells of the tubuli, and spermatogenesis has ceased; or, if any spermatozoa are to be found, these are badly stained and obsolete. During June the glands become smaller and firmer, and the whole microscopic picture is one of inactivity; they diminish still further in size during July and August, and acquire a yellow or brownish colour. This condition persists throughout September, during which month the bird

puts off the eclipse for the winter plumage. *During October and November, when the brilliant plumage is fully declared, the testes increase slowly in size, although they remain of a yellow or brownish colour, retain their firmness on section, and exude no fluid when incised. Spermatogenesis does not commence until December (perhaps the end of November); and the testes at first do not greatly increase in size. There is some variation as to the precise time at which spermatogenesis begins, but in any case the bulk of the testes greatly augments during the latter half of January and February. Evolution proceeds more and more rapidly during the second half of February, and March, until by the end of the latter month, or during April, the glands attain their maximum size.*

It must be understood that in the above account we have endeavoured to give an average picture of the annual evolution and involution of the testes, but there is no doubt that a considerable range of variation obtains in the time of the onset of spermatogenesis. Furthermore, in some birds, spermatozoa may be found in the testes at a somewhat later date than is usual; in such circumstances it is probable that spermatogenesis arose correspondingly late.

II.

Observations made to study the results of Castration upon the Plumage.

It was our intention to castrate a series of ducks in order to see whether any aberrations would result in the natural history of the plumage, but in spite of repeated attempts, it was found impossible to completely extirpate the glands. Every visible trace might be removed, after an extensive laparotomy, and yet, when the bird was killed some months later, a greater or lesser amount of regenerated testicular tissue was found either in the normal position or engrafted upon the neighbouring organs. The castration in every case was carried out under an anæsthetic.

The following experiments should all be read in the light of this fact, viz. that some regeneration of testicular tissue must have taken place within a few weeks or months of the operation; and since we do not know how small an amount of this tissue may be sufficient to exert an action on the body, we cannot say whether the results observed within the first few months of the operation would have persisted had the castration been complete. There are, however, certain considerations which lead us to believe that our results, in so far as they apply to the first six or eight months after the removal of all visible testicular tissue, are essentially comparable with those which would occur during this time were it possible to obviate the partial regeneration of the gland. In the first place the delay in the assumption of the eclipse in the birds submitted to operation from December to April (when the plumage is masculine), indicates that the removal of all visible testicular tissue has produced a definite effect on the bird;

whereas castration performed in July, while the testicles are retrograding and the bird is in eclipse plumage, produces no corresponding delay. Furthermore, the small size of the "grafts," or regenerated tissue, in birds killed from nine to ten months after operation, would indicate that the amount of testicular tissue, regenerated, and exerting its influence on the bird during the early months after the operation, must have been extremely small.

Our observations fall into two series according as the testes were removed, (A) while the bird was in full winter plumage, or (B) during eclipse.

(A.) The Results of Castration when performed on Birds whilst in full Winter Plumage.

(No. 18.) (Text-fig. 1.) Bird in full winter plumage; castrated in December 1906. The testes removed showed active mitosis and spermatogenesis in many tubuli.

June 9th, 1907.—Bird in full plumage, with glossy vertex, and one very glossy feather in tail*. The only sign of approaching eclipse is a slight brownish-yellow tinting of some of the speckled feathers on the belly.

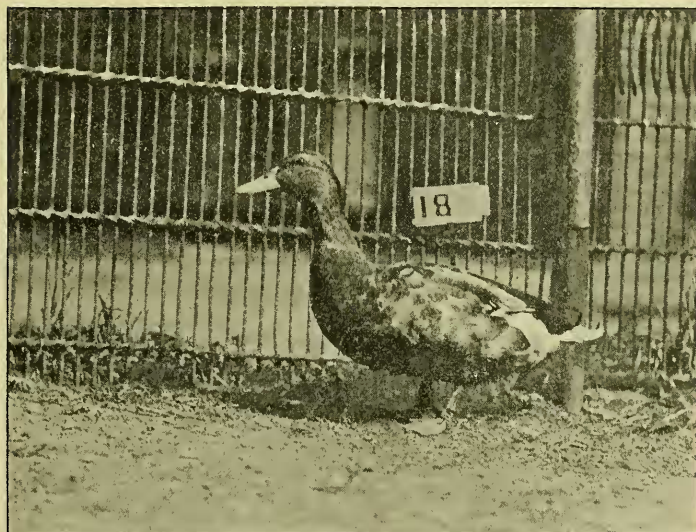
July 11th, 1907.—Full plumage unmodified except that there is a diffuse light brown coloration of the abdomen: this is not due to any growth of new feathers but to a pigmentary modification in the old. There are two curl feathers in the tail and a third forming.

July 28th, 1907.—The general appearance of the bird is still that of a male in full plumage; and the white ring on the neck is as marked as ever it was, but there are a few brown feathers on the cheeks (first noticed on July 23rd), and a strong flush of eclipse feathers in the maroon area on the breast, which is becoming somewhat lighter in colour. A number of eclipse feathers are obvious upon the abdomen; these are mostly old feathers in which pigment changes have taken place; the great majority of feathers on the abdomen are still vermiculated. There are a few new eclipse feathers in the scapular region. The tail contains two curl feathers and one partially curled.

August 1st, 1907.—Eclipse progressing very slowly; the head is in much the same condition as it was when last noted. The breast has perceptibly lightened, light brown feathers barred with black alternating with the dark maroon feathers; a few typical eclipse feathers are coming through the down of the breast. The scapulars have somewhat darkened, and there are more barred feathers upon the flank, each showing up as blotched with dark, upon the grey vermiculated background of the older feathers. These dark feathers appear to be new. Tail as last described. Although grey vermiculated feathers predominate upon the abdomen, they are intermixed with a number of brownish feathers with black centres: some of the latter are new; others are due to pigment changes.

* On May 14th there were three curl feathers in the tail.

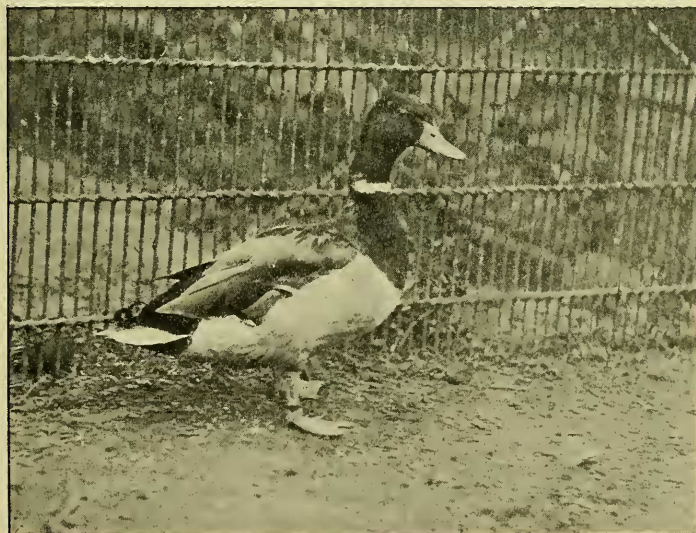
Text-figure 1.



The Mallard (No. 18) as it appeared on August 27th, 1907; castrated in December 1906.

The eclipse is far from complete, *i. e.* it has been delayed by the castration; the curl feathers have not as yet been lost, nor has the white ring on the neck fully disappeared, etc.

Text-figure 2.



Normal Mallard in full winter, or non-eclipse plumage.

August 11th, 1907.—Gloss on head limited; small irregular areas of it on sides of face and neck; white ring faintly represented at sides, absent in front and at back. The eclipse plumage is spreading rapidly upon the breast; this does not, however, present a typical appearance, although most of the feathers are brown with black centres, and the new ones coming through the down of the breast are of the eclipse type. There is no new flush upon the abdomen, though there are many brown feathers upon the flanks, where vermiculated feathers still prevail; it is not clear whether these brown feathers are new or not. In both wings the primaries, secondaries, and tertiaries are being rapidly moulted. Curly feathers are present in the tail.

August 18th, 1907.—No flight-feathers remain in either wing.

August 24th, 1907.—The eclipse on the body is not obviously proceeding. The curly feathers are still retained in the tail.

September 1st, 1907.—There is still a good deal of gloss on the vertex and the nape; the white ring is slightly indicated at the sides of the neck, not at the back or front. The breast is in almost full eclipse; the change is certainly largely due to the appearance of new feathers, but in part seems to be due to pigmentary change in the old. The feathers of the abdomen are, some eclipse, some vermiculated; there are feathers of both kinds, including a plentiful flush of young vermiculated feathers, on the flanks. There are no curl feathers in the tail, though these were present five days ago. The two central feathers are dark and glossy, and are beginning to ridge; the other tail-feathers are glossy, as they always have been.

September 12th, 1907.—The general aspect of the bird is intermediate; the majority of the breast-feathers that are fully grown are eclipse; there is, however, an abundant flush of young winter feathers coming through, although these do not yet affect the colour of the plumage. The vertex and the nape are glossy, but the cheeks present only a very few flecks of gloss; there is no trace of the white ring on the neck. Most of the feathers on the abdomen and posterior part of the breast are vermiculated; practically these are all old, but among them there is an abundant flush of young vermiculated feathers coming through: the eclipse feathers are few in number. On the flanks the feathers are almost entirely vermiculated, but many of them are tipped with brown, including a number of old (eclipse) feathers; new vermiculated feathers are coming through the down. The tail-coverts and back are glossy, with abundant new tail-coverts coming through. There are no curly feathers in the tail, but the central feathers are ridging and becoming glossy.

September 21st, 1907.—The general appearance is that of a bird in winter plumage, with the exception of the head and breast, for the majority of the breast-feathers are of eclipse type, in spite of a flush of winter feathers coming through and a considerable number of winter feathers which have already expanded.

The head has only a slight amount of gloss; the cheeks are only slightly flecked with the same. The feathers of the abdomen are predominantly vermiculated, a few eclipse feathers being left among them. The tail has one good curl feather and another ridging.

September 25th, 1907.—The head and neck are almost entirely glossy; the white ring is appearing, but the feathers of the breast are still largely of eclipse pattern, though many young feathers have come through. Among the vermiculated feathers of the abdomen a few eclipse ones are still present; practically all the young winter feathers have come through. The scapulars are unaltered. There are two curl feathers in the tail, and a third is ridging; the tail-coverts are glossy green, more so than when last described.

November 12th, 1907.—The bird is in full male winter plumage, with good curl feathers in tail. The only trace of the eclipse is to be found on the flanks, where there are still a few feathers tipped with brown and a few brown feathers which are not vermiculated at all. This bird was allowed to live until the end of July 1908, by which time, had it been a normal bird, it should have been in full eclipse, or even have been passing out of it.

The following note was made on July 27th, 1908:—The bird is in full eclipse, though there is a slight gloss upon the vertex. The breast is in eclipse, but there are a good many partially vermiculated feathers in the lower part of the breast and on the abdomen; there are no young feathers coming through. There are no curl feathers in the tail, but the two central are becoming glossy and beginning to ridge. The primaries and secondaries of the wing have been shed; the young feathers are not fully developed; the feathers of the flank are vermiculated, mixed with eclipse. The bird was killed and examined on July 30th, 1908. On the right side there was a series of loosely attached nodular grafts, which in total volume are about the size of a haricot; they were of a dull yellow, and brown on section. On the left side there were two small nodules, which, together, are the size of a small pea; there are other grafts, viz. at the root of the liver and attached to the mesentery; both these are of the size of small peas. All the testicular tissue is of a dull yellow colour.

(No. 13.) (Text-fig. 3, p. 35) Bird in full winter plumage; castrated December 20th, 1906. The testes removed were brown in colour, and did not exude fluid on section. Microscopically the tubules have a wide lumen and a many layered lining, with smaller cells about the centre. There are no spermatozoa, but mitotic figures occur in certain of the cells.

July 11th, 1907.—The general appearance of the bird is that of a male in almost full plumage. The vertex is dark green, though not definitely glossy; the cheeks are flecked with brown, but the white ring on the neck is perfect. There is a slight

lightening of the lower breast-feathers, and the feathers of the abdomen are generally somewhat browner and less grey than in the male in full plumage. There are four perfect curl feathers in the tail; the wing-feathers have not been shed, and are still quite firm.

September 11th, 1907.—Vertex dark, slightly glossy; only a few flecks of gloss on the cheeks; the white ring round the neck, just beginning to show after having disappeared. The breast is in eclipse; there is a moderate flush of young eclipse feathers coming through. The abdomen is in eclipse. The flank-feathers are almost entirely eclipse, but a few are in part vermiculated. There are no curl feathers in the tail (text-fig. 4).

January 24th, 1908.—Although the general appearance of this bird is predominantly that of a male in winter plumage, there are many signs that the eclipse is only slowly passing off. The vertex is dark, but it can scarcely be described as glossy, though the rest of the head is generally so, with only a few brown feathers remaining. The white ring, however, round the neck has now become well marked. There is much eclipse plumage left on the breast and abdomen. The flanks are in partial eclipse, a number of incompletely vermiculated feathers being present. The tail contains one poorly developed curl feather; the three other central feathers are dark and beginning to ridge—the first stage in the formation of the curl.

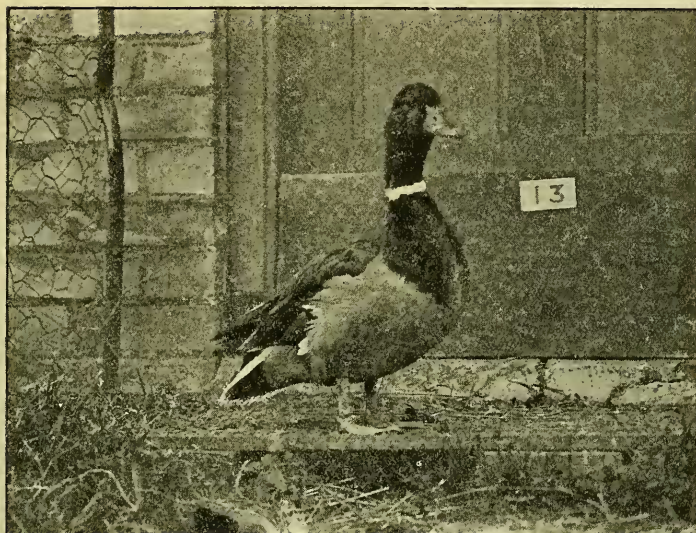
(No. 2.) Bird in full winter plumage; castrated December 20th, 1906. The testes removed were brownish yellow, and did not exude fluid on section. The tubuli were full of cells, and though no spermatozoa were present there were abundant mitoses.

July 11th, 1907.—Although the general appearance is that of a bird in winter plumage, it is modified by a considerable flecking with brown feathers on the sides of the face, and by the occurrence in the anterior portion of the grey of the breast, of individual feathers of a dull black edged with brown. The vertex is glossy, and there are four perfect curl feathers in the tail.

The photograph of this bird (text-fig. 5, p. 36), taken on September 11th, 1907, shows that the assumption of the winter plumage was delayed. The plumage is predominantly eclipse. There is no gloss on the head, and although the central tail-feathers are beginning to ridge, by far the greater number of the feathers on the head, belly, back, and shoulders exhibit wholly or in part the dusky coloration of the eclipse.

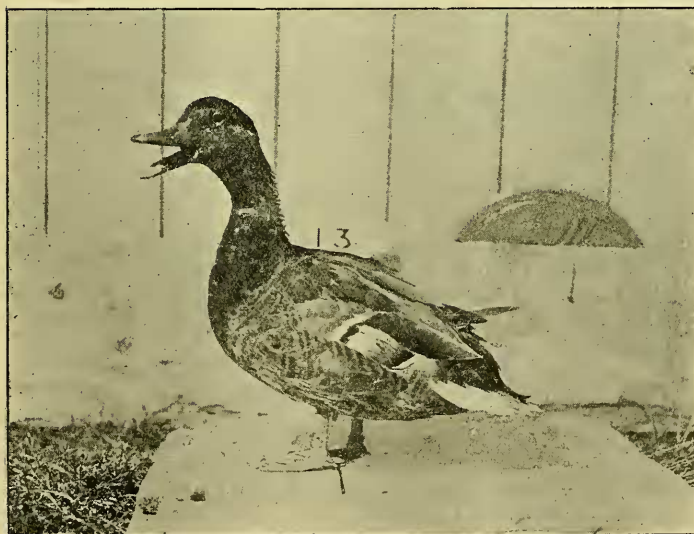
September 11th, 1907.—The vertex is dark and only slightly glossy; a few flecks of gloss are present upon the cheeks. There is no white ring on the neck. The feathers on the breast are predominantly eclipse, but here, and on the abdomen, there are feathers which are partially vermiculated, and there is an abundant flush of fresh vermiculated feathers coming through; among them there are a few eclipse feathers. The flanks contain many eclipse feathers and some new vermiculated ones. There

Text-figure 3.



Mallard (13), photographed in July 1907; in almost full winter plumage. The bird was castrated in December 1906. The eclipse has been delayed.

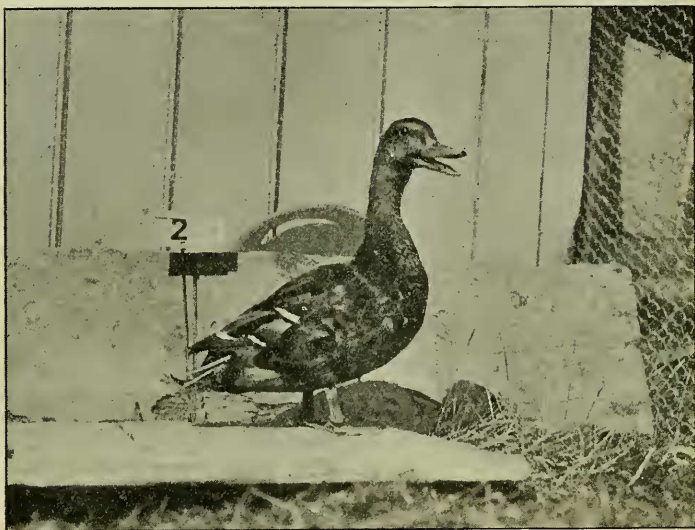
Text-figure 4.



The same Mallard as shown in text-fig. 3: photographed September 11th, 1907. The bird was castrated in December 1906. The advent of the eclipse in the summer of 1907 was delayed. The plumage is now largely of the eclipse kind; the bird was not fully out of eclipse in January 1908, before which time it should normally have been in complete winter dress.

is one glossy curl feather in the tail, probably new; two other feathers are beginning to ridge. Tail-coverts glossy.

Text-figure 5.



Mallard (2), photographed September 11th, 1907.

The bird was castrated in December 1906. The advent of the eclipse in the summer of 1907 was delayed. The photograph shows that the passage from the eclipse to the winter plumage is also delayed; the plumage is still predominantly eclipse; the vertex was only slightly glossy; the white ring has not reappeared on the neck; there was but one curl feather in the tail.

January 24th, 1908.—Bird completely male; four good curl feathers in the tail. On the flanks there is an occasional feather of a dusky brown colour with obscure vermiculations.

This bird was killed on February 19th, 1908, when a spheroidal graft, 6 mm. in diameter, was found in the abdomen. The tubuli of the graft were of full size, and active spermatogenesis was in progress.

(No. 48.) Bird in full winter plumage; castrated March 6th, 1907.

May 14th, 1907.—Bird in full plumage, with three curl feathers in the tail. The only premonition of the eclipse is a slight browning of some of the interscapular feathers and those upon the lower part of the breast.

July 11th, 1907.—The plumage has undergone but little

change, though the lustre has partly disappeared from the vertex, which is dark; and there is a little lightening of the lower chestnut feathers of the breast, which are tipped with white. There are three perfect curl feathers in the tail, and the old wing-feathers are quite firm and exhibit no tendency to be shed.

August 18th, 1907.—Much of the gloss on the vertex, and some of that on the cheeks, is retained; the breast is partly in winter, partly in eclipse plumage; the abdomen is in full winter plumage. There are some dark feathers on each flank.

September 11th, 1907.—The general aspect is that of a bird not quite in winter plumage; the head and neck are partially glossy, though there is still a good deal of brown upon the cheeks. There are some eclipse feathers in the breast, but the greater part are vermiculated and more winter feathers are coming through the down. The abdomen and the posterior part of the breast are completely vermiculated. There is one curl feather in the tail, and the tail-coverts are glossy. This bird was killed on September 12th, 1907. It presented a single graft the size of a small haricot: the tubuli were large and full of cells; in every tubule spermatogenesis was in active progress.

(No. 7.) Bird in full winter plumage; castrated April 5th, 1907. The testes were large and very soft, as when in full activity during this month.

On April 21st it was noted that there was a brownish wash-like tinting of feathers on the lower breast and abdomen.

July 27th, 1907.—Eclipse not complete. Some gloss on the vertex and cheeks; the white ring has disappeared. The chestnut area of the breast is only partially in eclipse. A number of eclipse feathers are coming through, though many look vermiculated. A large number of vermiculated feathers persist in the flanks, and there are many new vermiculated feathers in this position. Vermiculated feathers are coming through at the bases of the wings. The hinder part of the breast is greyish rather than vermiculated; no new feathers are coming through here. There are no curl feathers in the tail; the central feathers are ridging. The wing-feathers do not appear to have been as yet shed.

November 30th, 1907.—Bird in full male plumage; three curl feathers in the tail. The bird was killed and examined. There were a few encapsulated blood-clots about the site of operation, but no trace of the testes except two nodules situated close together and each the size of a millet seed. There were no nodules on the intestines or liver. Microscopic examination of the nodules referred to proved that they consisted of testicular tissue, some of the tubuli of which were distended with cells. No spermatozoa were present, and the central cells of the larger masses were degenerated.

(B.) The Results of Castration when performed on Birds
whilst in Eclipse Plumage.

(No. 11.) Bird in almost full eclipse plumage; castrated in July 1907. The head was in full eclipse, except that a few feathers on the side of the face showed a greenish gloss. The whole of the breast was in complete eclipse, with young eclipse feathers coming through in the anterior part. There were a few vermiculated feathers at the base of the neck behind. The primaries and secondaries had been shed from both wings, and there were no curl feathers in the tail, though a little gloss remained on the tail-coverts. The testes removed were about 22 mm. by 8 mm. in diameters, yellow in colour and firm on section.

September 17th, 1907.—The head has passed into almost complete winter plumage, although a few brown feathers are still present. The upper part of the chestnut area of the breast is in full winter plumage, though a considerable number of eclipse feathers are still present in the lower part of it. The grey portion of the breast and the abdomen are almost entirely vermiculated, though a few eclipse feathers are still present. Over the area plucked for operation in July the feathers are only faintly vermiculated and are of a greyish brown. There are two good curl feathers in the tail.

November 8th, 1907.—The bird was in full winter plumage, with four curl feathers in the tail. It was now killed. A graft the size of a small haricot was found at the site of the right testis.

(No. 12.) Bird in almost full eclipse; castrated July 1907. The testes were about 22 mm. by 8 mm. in diameters; pale yellow in colour and firm on section. The head is in almost complete eclipse, only the slightest glossiness persisting at the vertex. The chestnut area of the breast is in complete eclipse, with a few eclipse feathers still coming through the down; the rest of the breast is predominantly eclipse, although a few of the old vermiculated feathers persist. On the flanks there are both vermiculated and eclipse feathers. The wing-feathers have not been shed; there are no curl feathers in the tail. A good deal of gloss persists upon the upper tail-coverts and the feathers of the saddle.

September 17th, 1907.—The condition of this bird resembles that of the preceding (No. 11), with the following exceptions:—The head is not quite so advanced towards winter plumage, and the ring on the neck is not so well marked; there are fewer eclipse feathers in the lower part of the chestnut area; and there are three curl feathers in the tail.

November 8th, 1907.—Bird in full male plumage, with four curl feathers in the tail. It was now killed; at the site of the right testis there were three small grafts, one about the size of

a carraway seed, and two others about the size of a grain of maize and of a hemp seed respectively.

(No. 19.) Bird in full eclipse; castrated July 12th, 1906. The testes removed were of medium size, 15 mm. in longer diameter; the weight of each was about 3700 mg. The tubuli were fairly large, and distended with cells, without lumen. Here and there the spermatid sheaf arrangement was indicated. There were, however, no properly formed and stained spermatozoa.

September 11th, 1906.—Bird in almost full male plumage, except that the stippling on most of the vermiculated feathers has not attained its full darkness, and that the majority of these feathers are tipped with white.

January 24th, 1907.—Bird in full male plumage; there are two curl feathers in the tail.

April 4th, 1907.—Bird in full male plumage.

July 27th, 1907.—Bird in almost full eclipse, though there is a slight gloss on vertex. The grey upper portion of the breast is in eclipse, which must, however, be considered to be passing off, since there are many winter feathers coming through the down. The abdomen and the hinder part of the breast, eclipse. The wing-feathers have been moulted, but the new primaries and secondaries are not yet fully grown. There are no curl feathers in the tail.

The bird was killed on July 30th, 1907. On the left side there was a nodule the size of a small haricot, loosely connected with the great veins below the normal site of the testis. A group of grafts, together as large as a filbert, was loosely attached to the back of the liver.

(No. 13.) Bird in full eclipse; castrated July 8th, 1907. The testes removed were quite small, scarcely 10 mm. long by 5 mm. broad. The tubuli, of comparatively small size, were furnished with a well-differentiated lumen; cells two or three deep: no spermatozoa.

September 17th, 1907.—The bird still retains much of the eclipse plumage; there are some glossy feathers on the vertex and round the eye, but the rest of the head and neck are in definite eclipse, and the neck shows only the faintest remains of a white ring. The breast and the abdomen are in eclipse, though in both positions a few vermiculated feathers are coming through. The area which was plucked for the castration is slightly darker than elsewhere. On the flank many of the brown eclipse feathers are becoming vermiculated, and new vermiculated feathers are, in addition, appearing. There are no curl feathers in the tail; the moult of primaries and secondaries in the wings has been much delayed, as the new feathers have not yet attained their full size, and their shafts are still vascular.

November 18th, 1907.—The head is glossy, but many feathers on the cheeks are still partially brown; the white ring on the

neck is well developed. The chestnut area of the breast contains so many eclipse feathers that the general appearance of this part is eclipse, but there are also a few winter-plumage feathers intermixed. The lower part of the breast, though generally vermiculated, shows a small number of eclipse feathers. The area on the abdomen plucked in July for castration is covered with feathers, darker than elsewhere and only partially vermiculated; it might perhaps be described as "semi-eclipse" in character. A few eclipse and partially eclipse feathers persist in the flank. The tail contains two good curl feathers, and two others are ridging; all are glossy, as well as the tail-coverts. The bird was killed on this day. On the left side there was no trace of testicle, but on the right there was a nodule the size of a large haricot at the site of the gland, and below this a second, no larger than a millet seed.

Summary of the Effects of Castration upon the Plumage.

If we take the condition of No. 18 for the seven months succeeding the castration carried out early in December 1906, whilst the bird was in full male plumage, it appears that at the end of July 1907 (when the normal mallard has been in eclipse for some weeks) this bird still remained in almost full winter plumage. A careful water-colour drawing, made on July 23rd, 1907, by Mr. Norman H. Hardy, shows a bird in complete winter plumage, except for some small areas of brown on the cheeks and round the eyes, and a slightly diffuse tinting with brown of some of the vermiculated feathers on the abdomen. This bird, however, had passed through its eclipse, and had reassumed the full male plumage by September 21st. In July 1908, *i. e.* the following year, it passed into eclipse like a normal bird. The record of No. 13, castrated during the latter half of September, when the bird was in full male plumage, shows a similar result; but in this case the delay in the appearance of eclipse feathers was even more marked than in No. 18; while in both the birds not only was the eclipse delayed, but it was incomplete.

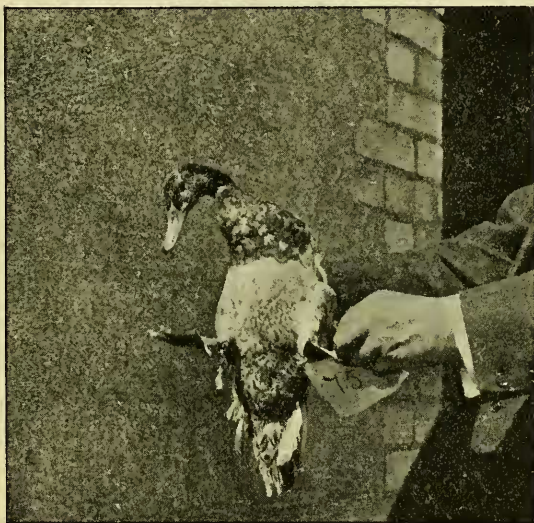
The behaviour of No. 48, castrated in March 1907, resembled that of No. 18, though the delay in the onset of the eclipse was not so marked; in No. 7, the testes of which were removed in April 1907, there was comparatively little delay.

Whilst there can be no doubt that the removal of the testes during the period of the eclipse does not retard the assumption of the proper male or winter plumage; castration carried out, on the contrary, whilst the bird is in full male plumage delays the appearance of the eclipse. This delay is not so much a positive delay as an abnormal persistence of the winter plumage. For if the winter feathers be plucked (*i. e.* artificially shed), the new feathers that replace them are of the typical eclipse kind.

Text-fig. 6 shows a bird concerning which it is no exaggeration

to say that half the area on the breast and abdomen, which is normally vermiculated, exhibits the eclipse plumage, while the rest is in male or winter plumage. This bird (No. 75) was castrated in May. In the middle of July its general appearance, whilst standing, was quite male, for the only obvious sign of the oncoming of the eclipse was a slight loss of the gloss on the vertex of the head and a browning of the cheeks; the curl feathers in the tail were still unshed—*i. e.*, the appearance of the eclipse was delayed, as usual, after castration. But on lifting up the bird, it was seen that the abdomen and breast, where they had been plucked for castration in May, were covered with a thick growth of buff and black eclipse feathers. Although this is the most marked example of the growth of eclipse feathers in plucked areas of castrated birds otherwise in winter plumage, we have seen the same thing in a less degree in other cases.

Text-figure 6.



A Mallard (75) castrated in May.

The abdomen and lowest part of the breast (plucked under ether anaesthesia for castration) have become (middle of July) covered with a growth of buff and black eclipse feathers, the plumage being otherwise of the winter kind. *i. e.* the appearance of the eclipse elsewhere has been delayed.

The ducks distinguished as Nos. 18, 48, and 69 were killed during late summer or early autumn, *i. e.* at a time when the testes are normally in an inactive condition. We unfortunately omitted to examine the histological condition of the "grafts" in No. 18, killed July 30th, 1908; but in the case of No. 48, killed

on September 12th, 1907, spermatogenesis was in full progress in the graft, a condition of activity which does not occur under normal conditions at this period of the year.

In the case of two additional castrated birds (not further recorded in this paper) which were killed between the end of June and September 1907, spermatogenesis was likewise taking place in similar grafts: *i. e.*, at a time when in normal birds the testes are functionless, at least as regards their external secretion. The histological condition found in the grafts in these different birds is shown in the following table:—

(No. 8 *m.*) Killed: June 1907 (late).

Condition of grafts:

One graft about the size of a small gooseberry; the tubuli are of large size and distended with cells; mitotic figures fairly abundant. In the centre of one tubule is a group of deeply-stained filaments with bulbous ends, which must be considered spermatozoa.

(No. 39.) Killed: September 12th, 1907.

Condition of grafts:

One graft about the size of a large pea. This consists of the epididymis and testicular tissue, the tubuli of which are of full size; spermatogenesis is in active progress.

(No. 48.) Killed: September 12th, 1907.

Condition of grafts:

One graft the size of a small haricot. The tubuli are large and distended with cells; in every tubule spermatogenesis is in full progress.

(No. 22 bis.) Killed: Mid-September 1907.

Condition of grafts:

Graft consists of closely-set tubuli of large size and full of cells. Spermatogenesis with well-developed spermatozoa present in some of the tubes: in other tubuli the centre is filled with a vacuolated mass of cell-débris without spermatozoa.

Conclusions.

I. In the male of the Wild Duck the testes undergo annually a series of seasonal changes (as in many other birds), and are spermatogenic only during the winter months and early spring.

II. The periods of activity and non-activity do not coincide with the two seasonal changes in the plumage.

III. The normal passage of the bird from full winter (breeding) plumage to its dusky summer (eclipse) plumage is, however, delayed if castration is carried out during the months whilst the gland is assuming, or has attained, its activity.

One bird (No. 18) which was castrated in the winter, and in which the advent of the succeeding eclipse was delayed the following summer, was kept until the summer of the next year.

In this case the second eclipse occurred at the normal period.

As, however, small nodules of regenerated testicular tissue were found at the autopsy (as indeed they were in every other case), we are not at present in a position to say whether a Mallard which is absolutely without testicular tissue will continue to pass through the same seasonal changes of plumage as the normal bird.

It is a remarkable fact that the grafts were fully spermatogenic in the month of September, an occurrence altogether abnormal in the testicle of the entire bird. We can offer no explanation of this anomaly.

The delay above referred to has its parallel in the well-established fact that if a colt is castrated when shedding its winter coat, the shedding is for a time arrested, and then proceeds only very slowly.

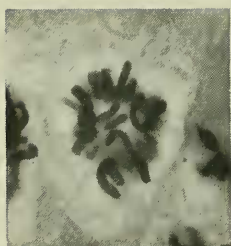
It is of interest to observe here that in the case of the Wild Duck, when females assume the male plumage (a phenomenon well known also in the Common Pheasant and other birds), the spurious males undergo the seasonal eclipse, although this is somewhat incomplete and aberrant.

IV. Removal of the testes during the eclipse does not produce any constant, appreciable effect upon the next passage of the bird into winter plumage.

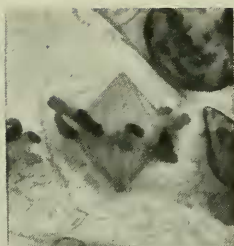
It would appear from these observations that the seasonal change of plumage in the Mallard is not connected with the spermatogenic function of the testicle.

But whether a second function of the organ, viz. the production of an internal secretion, or hormone, is responsible for the change, could only be proved by castration so effectively carried out as to exclude absolutely any reproduction of testicular tissue.

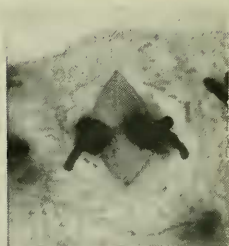
The only method of ensuring this is to reopen the abdomen after the castration, and remove any nodules of reproduced tissue. Our results in this direction we may lay before the Society on some future occasion.



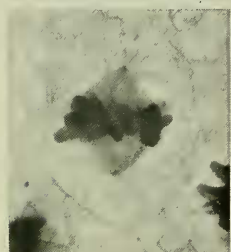
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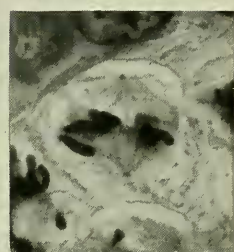
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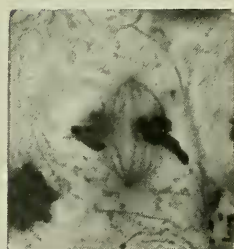
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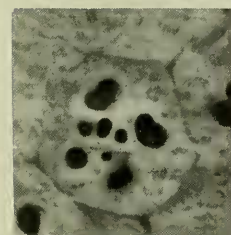
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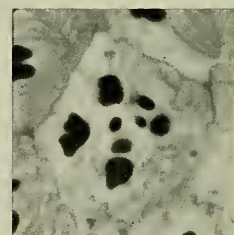
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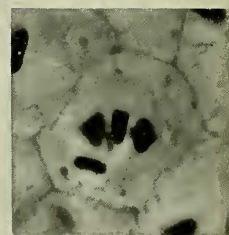
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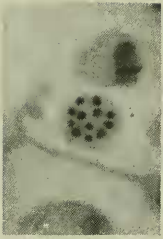
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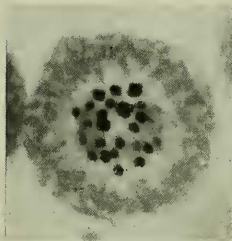
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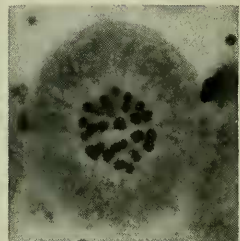
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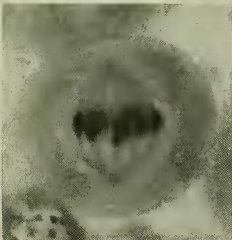
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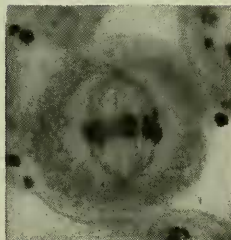
18.



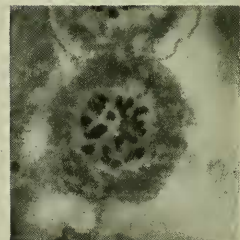
19.



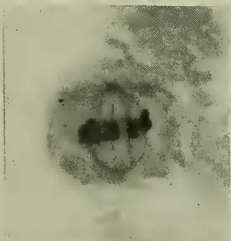
20.



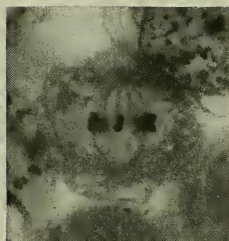
21.



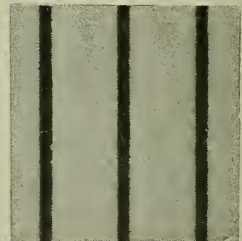
22.



23.



24.



25.

3. The Possible Connection between Spindle-Length and Cell-Volume. By C. F. U. MEEK, M.Sc., F.L.S., F.Z.S.

[Received October 31, 1913 : Read February 17, 1914.]

(Plates I. & II.*)

INDEX.

Cytology.

Introduction.

I have stated that in *Forficula auricularia* and *Helix pomatia* the ratio between the lengths of the mitotic spindle at the conclusion of the two spermatocyte metaphases is identical, or almost identical, with the ratio between the radii of two spheres of which the volume of one is equal to twice that of the other; and the same ratio has been observed by von Winiwarter in the spermatocyte metaphases of Man. Since each primary spermatocyte divides to form two daughter secondary spermatocytes, and since no period of growth seems to separate their mitoses, the volume of the primary spermatocyte cell in the metaphase is presumably equal to twice that of the secondary spermatocyte. Connection is therefore suggested between the spindle-length and cell-volume at this stage.

Although this ratio has been observed in organisms representing three phyla of the animal kingdom, the inference is speculative; for coincidence may be responsible for the apparent connection. I pointed out in an earlier paper that only one generalisation seemed to have been established concerning the mitotic spindle, namely, that it is not a figure formed entirely by the action of forces at its poles. We have since found that its length at the conclusion of spermatogenetic metaphases cannot be correlated with the volume of the chromatin; and, if we can eventually prove that the length at this stage is or is not connected with the volume of the cell, we shall have succeeded in establishing another generalisation.

In a paper on chromosome dimensions, published in 1912, I stated that increasing somatic complexity of the organism seemed to be accompanied by increase of chromatin volume in the germ-cell. The measurements given, however, proved that no theory depending entirely upon a quantitative analysis can suffice; for, in certain cases, the difference of chromatin volume in widely separated organisms was found to be less than that in organisms belonging to sister families.

I now intend to compare the volumes of spermatocyte cells in *Helix pomatia*, *Forficula auricularia*, *Triton cristatus*, and Man—organisms representing three phyla; and, in order that a comparison may be possible also in organisms belonging to allied

* For explanation of the Plates see p. 49.

families, I have included in Pl. I. photo-micrographs of spermatocyte cells of two species of *Stenobothrus*, of which the family is sister to that of *Forficula*. We know that the length of the spindle in spermatocyte metaphases cannot be correlated with the degree of somatic complexity of the organism; and, from the investigations now to be carried out, we shall know if the volumes of these cells cannot be so correlated. Moreover, the photo-micrographs of cells in *Forficula auricularia* and *Helicopomatia* will afford opportunity of verifying my original measurements of spindle-lengths at the conclusion of the metaphase.

Material and Methods.

All material was fixed in Flemming's strong chromo-aceto-osmic acid fluid, in which it remained for twelve hours. It was then washed for twenty-four hours in running water; and, after being passed through successive strengths of alcohol, was embedded in paraffin. Sections were cut 8 or 10 μ thick with a Cambridge rocking microtome.

The slides were stained for either twelve hours in Heidenhain's iron hæmatoxylin, or fifteen hours in iron brazilin. In the former case the mordant was an aqueous solution of ferric alum, and the slides remained in it for four hours; in the latter case they were put for two hours into a solution of ferric alum in 70 per cent. alcohol. The iron brazilin enables spindle fibres to be seen distinctly, and is a useful stain when camera-lucida drawings or photo-micrographs are required.

The preparations were studied with a Zeiss apochromatic oil-immersion objective of 3 mm. focus and N.A. 1.40, and the various compensating oculars. The light was obtained from a Graetzin lamp, and was passed through the holoscopic oil-immersion substage condenser made by Messrs. Watson & Sons of London. With one exception, all photo-micrographs shown were made at the same magnification with a Zeiss camera, the apochromatic objective mentioned above, and compensating ocular No. 4. The camera extension was 50 cm. The magnification was estimated with a stage micrometer graduated to read one hundredth part of a millimetre, and a photo-micrograph of this scale is included in Pl. II. The negatives and prints have not been retouched.

A Comparison of the Volumes of Spermatocyte Cells in different organisms.

Figs. 1-24 of the Plates are polar and lateral views of cells in the metaphase or earliest anaphase.

Figs. 1-8 inclusive represent spermatocyte cells in *Triton cristatus*. Fig. 9 represents a primary spermatocyte cell in *Stenobothrus viridulus*, and cells of this generation in *S. curtispennis* are shown in figs. 10, 11, & 12; in fig. 12, which is a lateral view, the odd or heterotropic chromosome is seen passing

undivided to one pole. The primary and secondary spermatocyte cells of *Forficula auricularia* are respectively represented by figs. 13, 14 and 15, 16, 17. Figs. 18 to 21 show the primary spermatocytes of *Helix pomatia*, and the secondary spermatocytes are shown in figs. 22 to 24.

Now, exact measurements of cell-volumes cannot be made; but it is evident from the photographs that, in the metaphase, the primary spermatocyte cells of *Triton cristatus*, *Stenobothrus viridulus*, *S. curtippennis*, and *Helix pomatia* differ from one another only slightly in size, and are considerably larger than those in *Forficula auricularia*. Moreover, drawings sent to me by Dr. von Winiwarter show that in Man these cells are smaller than those of *Triton*, *Stenobothrus*, and *Helix*. And the same results are obtained if we compare the secondary spermatocyte cells.

In the circumstances, we must realise that cells of these two generations may be of similar sizes in widely separated organisms, and of very different sizes in organisms that are closely allied; and increasing somatic complexity of the organism is not necessarily accompanied by increase of the volumes of these cells.

The Length of the Mitotic Spindle at the Conclusion of the Spermatocyte Metaphases of Helix pomatia (Pl. II. figs. 18-24) and Forficula auricularia (Pl. II. figs. 13-17).

We will deal first with spindle-lengths in *Helix pomatia*. Figs. 18 & 19 are polar views of the equatorial plate in the primary spermatocyte metaphase. Figs. 20 & 21 are lateral views, showing constriction of the chromosomes in progress. I estimated the spindle-length at the conclusion of this metaphase to be 15.3μ ; and, since the length found from these two photographs for the slightly earlier stage is 15μ , my original measurement seems to have been accurate.

Fig. 22 is a polar view of the equatorial plate in the secondary spermatocyte metaphase. Fig. 23 is a lateral view of the spindle at the conclusion of this metaphase. The spindle-length at this stage was said to be 12.1μ , and this measurement is now verified; for I am not attempting in this paper to express spindle-lengths in terms smaller than half a micro-millimetre, and the length found from the photograph is 12μ . Fig. 24 shows a slightly later stage, when the anaphase has begun; the length of the spindle in this cell is found to be 12.5μ .

Let us now consider the spindles of *Forficula auricularia*. Fig. 16 is a polar view of the secondary spermatocyte complex; ten chromosomes are arranged on the periphery of the spindle, and two lie within it. Figs. 15 & 17 are lateral views of this mitosis; the chromosomes are constricting in the equatorial plane, and the stage depicted therefore immediately precedes the conclusion of the metaphase. The length of the spindle,

estimated from the magnification, is $8\ \mu$ in each cell, and this confirms my original measurement; for the length was said to be $7.8\ \mu$ during constriction and $8.1\ \mu$ at the moment when constriction was complete.

Fig. 13 is a polar view of the primary spermatocyte complex, and all the chromosomes are shown. Fig. 14 is a lateral view at the conclusion of the metaphase; the chromosomes have completed constriction, and the daughter rods are ready to move towards the two poles. This photograph has been made at a magnification greater by $\frac{1}{3.5}$ th than that of the remaining figures. In my earlier paper the length at this stage was said to be $10.4\ \mu$; and, since the length, estimated from the photograph, is $10.5\ \mu$, my original measurement is seen to have been accurate.

There is, however, a new factor that must be considered in the case of this organism. I remarked in my paper that, at the conclusion of the primary spermatocyte metaphase, certain cells showed a spindle-length greater than that required by the ratio. Such spindles seemed to be distorted, and, after careful consideration, I assumed that they were abnormal in that their true form had been destroyed in the process of section-cutting. I have recently studied new preparations of this material, and have again found spindles of excessive lengths. These occur in cells that are closely packed together; but, since many of the spindles show no sign of distortion, we are not justified in assuming abnormality in every case.

Four explanations can be put forward. First, the volume of these cells in the metaphase may vary, and our proposition may still be valid. In this case, however, various lengths will presumably be found at the conclusion of the secondary spermatocyte metaphase; and I have not observed such lengths. Secondly, the daughter chromosomes may remain apposed to one another in the equatorial plane for a considerable time after constriction is complete: if centrosome divergence continues during this period, the various and excessive lengths may be explained. This, however, cannot always occur; for, in this organism, I have found and drawn primary spermatocyte cells in which the daughter chromosomes have begun to move towards the poles when the spindle-length is only slightly greater than that estimated for the conclusion of the metaphase. Thirdly, our proposition may require modification in that the length of the spindle may be affected by the shape of the cell. My original measurements in *Forficula* and *Helix* were made from cells that were approximately spherical, and this may explain the constant lengths observed. When, however, cells are closely packed together in a cyst, the spherical form disappears, and, if our modification is valid, the spindle-length will vary with the shape assumed. Lastly, the length of the spindle at this stage may be connected with neither the volume nor shape of the cell; and, in this case, our proposition is entirely disproved. If, however,

this is so, why has the ratio in question been observed in *Helix pomatia* and Man?

I hope to deal with these explanations in a subsequent paper. In the meantime, the proposition remains a suggestion.

BIBLIOGRAPHY.

MEEK, C. F. U.

1911. The Spermatogenesis of *Stenobothrus viridulus*. Journ. Linn. Soc., Zool. vol. xxxii.
1912. A Metrical Analysis of Chromosome Complexes, showing Correlation of Evolutionary Development and Chromatin Thread-width throughout the Animal Kingdom. Phil. Trans. Roy. Soc. ser. B, vol. cciii.
- „ The Correlation of Somatic Characters and Chromatin Rod-lengths, being a further Study of Chromosome Dimensions. Journ. Linn. Soc., Zool. vol. xxxii.
1913. The Problem of Mitosis. Quart. Journ. Micr. Sci. vol. lviii. Part 4.
- „ The Metaphase Spindle in the Spermatogenetic Mitoses of *Forficula auricularia*. *Idem*, vol. lix. Part 2.
- „ The Length of the Mitotic Spindle in the Spermatocyte Metaphases of *Helix pomatia*. Proc. Roy. Soc., ser. B, vol. lxxxvii. No. 594.

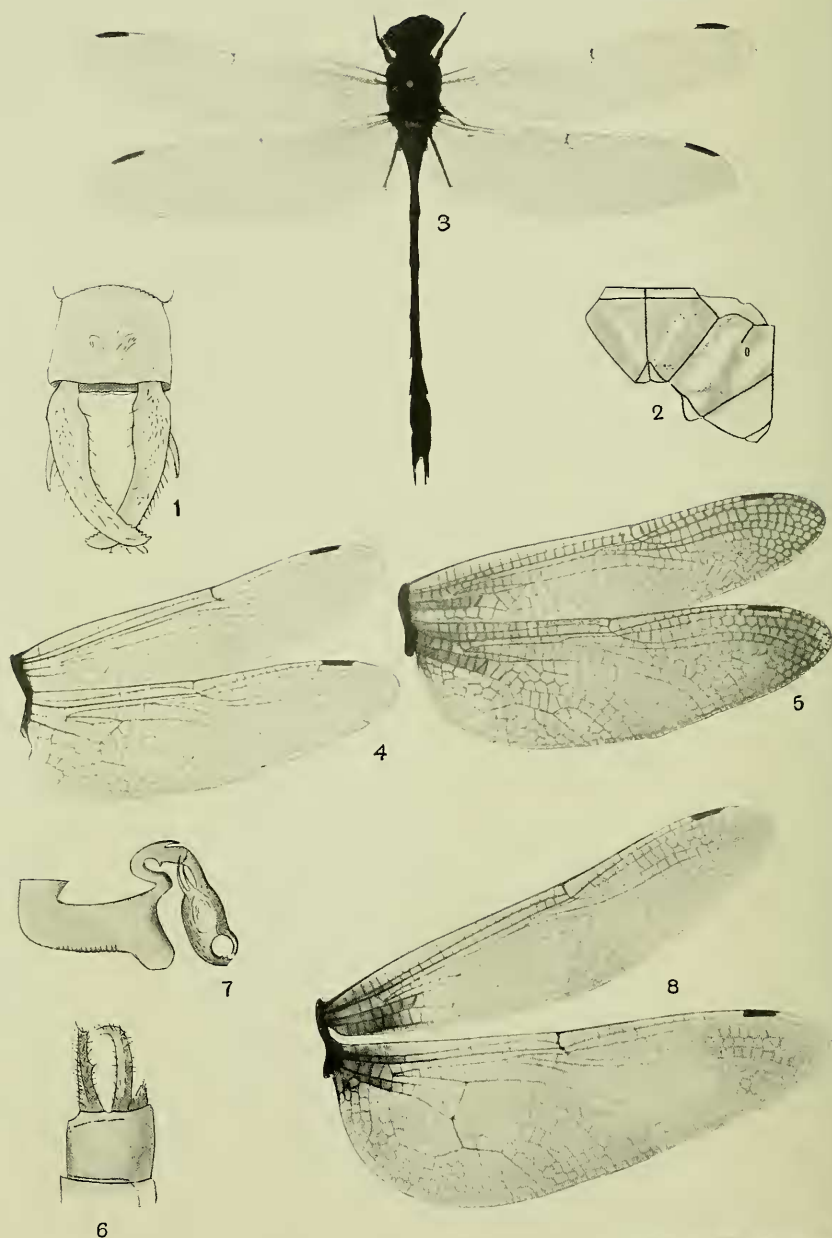
EXPLANATION OF THE PLATES.

PLATE I.

- Figs. 1-8. Polar and lateral views of spermatocyte cells of *Triton cristatus*, in the metaphase and earliest anaphase.
9. Polar view of equatorial plate in primary spermatocyte metaphase of *Stenobothrus viridulus*.
 - 10, 11. Polar views of equatorial plate in primary spermatocyte metaphase of *Stenobothrus curtipennis*.
 12. Lateral view of spindle in primary spermatocyte metaphase of *Stenobothrus curtipennis*; the odd or heterotropic chromosome is seen passing undivided toward the lower pole of the figure.

PLATE II.

- Fig. 13. Polar view of equatorial plate in primary spermatocyte metaphase of *Forficula auricularia*.
14. Lateral view of spindle at conclusion of primary spermatocyte metaphase of *Forficula auricularia*.
 16. Polar view of equatorial plate in secondary spermatocyte metaphase of *Forficula auricularia*.
 - 15, 17. Lateral views of spindle in secondary spermatocyte metaphase of *Forficula auricularia*.
 - 18, 19. Polar views of equatorial plate in primary spermatocyte metaphase of *Helix pomatia*.
 - 20, 21. Lateral views of spindle in primary spermatocyte metaphase of *Helix pomatia*.
 22. Polar view of equatorial plate in secondary spermatocyte metaphase of *Helix pomatia*.
 23. Lateral view of spindle at conclusion of secondary spermatocyte metaphase of *Helix pomatia*.
 24. Lateral view of spindle in earliest secondary spermatocyte anaphase of *Helix pomatia*.
 25. Divisions of stage micrometer, 10 μ apart, showing magnification of figs. 1-13 and 15-24.



University Press Cambridge.

4. Contributions to a Study of the Dragonfly Fauna of Borneo.—Part II. The Gomphinae and Chlorogomphinae.
By F. F. LAIDLAW, M.A., F.Z.S.

[Received October 18, 1913 : Read February 17, 1914.]

(Plate I.*)

	INDEX.	Page
Structure :		
Venation of <i>Orogomphus</i>		59
Geographical Distribution :		
Gomphinae and Chlorogomphinae of Borneo.....		51
Systematic :		
<i>Ictinus acutus</i> , sp. n.		51
<i>Burmagomphus vermiculatus</i> (Martin), <i>insularis</i> subsp. n.....		55
<i>Heterogomphus icterops</i> Martin, <i>borneensis</i> subsp. n. ?		57

Introductory remarks.—I have dealt at some length with the venation of the various species discussed below, more especially with the species belonging to the Chlorogomphinae; chiefly because all of them, and especially the latter, are very rare in collections, and because they are of particular systematic interest to the student of the Odonata.

With regard to the distribution of these members of the Dragonfly fauna, too little is known to admit of dogmatic statements or even of useful discussion. The genera which seem to be essentially characteristic of the Great Sunda Islands are *Macrogomphus* and *Microgomphus*, the latter unknown beyond their limits; all the other genera here recorded have a wide distribution in the Orient, and in the case of *Ictinus* beyond it. At the same time the Gomphine fauna of Tropical Asia is as sharply characterized as that of any other quarter of the earth.

ICTINUS ACUTUS, sp. n. (Selys nom.) (Pl. I. fig. 1.)

2 ♂♂. Baram, Oct. 1910.

Length of abdomen 45 mm. + 3 mm.; hind wing 36 mm.; pterostigma 5 mm.

Venation:—

An.n. $\frac{19 \text{ or } 20}{14 \text{ or } 15}$; Pn.n. $\frac{13 \text{ or } 14}{15}$; t. $\frac{3-4\text{-celled}}{3\text{-celled}}$; ti. $\frac{3 \text{ celled}}{1.2.2.3\text{-celled}}$; supr.t. $\frac{2}{2}$.

Belongs to the group *I. decoratus* de Selys.

Wings tinged with brown; orange at the base—in the fore wing for about one-third the length of the median space, but excluding the cubital space; in the hind wing almost up to the arculus. Pterostigma brown.

Head: Upper lip yellow, edged with black, the black reaching

* For explanation of the Plate see p. 63.

the base of the lip in the middle line; rhinarium yellow, marked below with a transverse black line. Nasus and frons brownish black; the former has a small round yellow spot on either side, the latter carries a pair of transverse yellow spots at its summit, these are separated narrowly in the middle line by black. Vertex and occiput entirely brownish black.

Prothorax very dark brown, its under surface and base of the prothoracic limbs paler.

Thorax rich chestnut-brown, marked with yellow as follows:—A mesothoracic half-collar divided by the black median dorsal carina; a dorsal stripe on either side, incomplete below, and an antehumeral stripe constricted at its middle; a narrow band on the mesepimeron and a second band, likewise narrow, on the metepisternum. Nearly the whole metepimeron is yellow, its posterior border narrowly marked with black, whilst the metasternum is entirely black.

Legs: Femora dark brown, the first pair with a narrow internal stripe; tibiae and tarsi black.

Abdomen largely black, segments 1, 2 brown below and at the sides, auricles brown, 2 with a yellow dorsal band narrowing to a point at the apex of the segment; 3, 4, 5, 6 black, each with a small basal yellow mark dorsally, which is triangular in shape with its apex directed backwards (in the more adult of the two specimens these markings are of a brown colour rather than yellow). Anterior third of 7 yellow dorsally, 8, 9, 10 largely brown at the sides; the distal half of 10 is also brown dorsally; laminae of 8 black.

Anal appendages black; upper pair fully equal in length to 9, 10 together, curved inwards a little and crossing each other like the blades of scissors. Each bears a strong sharp spine on its outer margin, rising at the junction of the inner and middle third of its length, and the inner margin of each is finely serrated near its apex. Lower appendage very short, almost concealed by the anal tubercle, abruptly truncate, with a small hooked spur on either side.

This fine form is well characterized by the anal appendages, which are unlike those of any of the described species. The type-specimen has been examined by M. René Martin, who has very kindly informed me that it is identical with an example in the de Selys collection labelled *I. acutus*, which has not been described.

(The type is in the British Museum; co-type, Sarawak Museum.)

**ICTINUS DECORATUS* de Selys.

Ictinus decoratus Selys, Hagen, Monogr. Gomph. p. 273, pl. 14. fig. 4; Kirby, Cat. Odonata, p. 77; Krüger, Stettin. Entom. Zeitg.

* Species marked with an asterisk are those of which I have not received examples from Mr. Moulton.

1898, p. 315; Williamson, "Gomph. etc. of Burma," Proc. U.S. Nat. Mus. xxxiii. 1907, p. 279; Martin, Mission Pavie, p. 14 (sep.) (1904).

Recorded from Borneo (*Martin*), Sumatra (*Krüger*), Java (*Selys*), and Tonkin (*Martin*).

ICTINUS MELENOPS de Selys.

Ictinus melenops Selys, Hagen, Monogr. Gomph., pp. 532, 686, pl. 15. fig. 1; Selys, Addit. Synops. Gomph., Bull. Acad. Roy. Belg. 2. vii. 1859, p. 548; Karsch, Entom. Nachr. xvii. 1891, p. 244; Kirby, Cat. p. 77; Martin, Mission Pavie, p. 14 (sep.) (1904); Williamson, loc. cit. p. 280, figs. 7, 8, 29; Ris, Ann. Soc. Entom. Belg. lv. 1911, p. 239.

Ictinus melenops, race *sumatranus*, Krüger, Stettin. Entom. Zeitg. 1898, p. 315.

I have examined one female taken at Kuching in December 1899 (Sarawak Museum Collection).

The species is recorded also from Sumatra (*Karsch*, *Krüger*) and Malacca (*Martin*), Cambodia and Tonkin (*Martin*).

*GOMPHIDIA MACLACHLANI de Selys.

Gomphidia maclachlani de Selys, 2^{me} Addit. Synops. Gomph., Bull. Acad. Roy. Belg. 2. xxviii. 1869, p. 767; Kirby, Cat. p. 76; Krüger, Stettin. Entom. Zeitg. 1898, p. 314; Martin, Mission Pavie, p. 14 (sep.); Williamson, loc. cit. pp. 281-282.

Recorded from Borneo (*Selys*), Sumatra (*Krüger*), Tonkin and Anam (*Martin*).

*GOMPHIDIA KIRSCHI de Selys.

Gomphidia kirschi Selys, 4^{me} Addit. Synops. Gomph., Bull. Acad. Roy. Belg. 2. xlv. 1878, p. 673; id., Anal. Soc. Españ. de Hist. Nat. xi. 1882, p. 18; Kirby, Cat. p. 76; Martin, Mission Pavie, p. 14 (sep.); Williamson, loc. cit. p. 283.

Recorded from the Philippine Is. (*Selys*), Borneo (*Selys*), and Tonkin (*Martin*).

SIEBOLDIUS JAPONICUS de Selys.

Sieboldius japonicus Selys, Hagen, Monogr. Gomph. p. 224, pl. 13. fig. 3; Kirby, Cat. p. 76; Williamson, loc. cit. p. 285, fig. 11.

Sieboldius grandis Krüger, Stettin. Entom. Zeitg. 1898, pp. 311-314; Laidlaw, Proc. Zool. Soc. Lond. 1902, i. p. 81, pl. vi. fig. 33 a.

I have examined a male of this fine species, collected by Mr. Moulton. It agreed closely with the male taken by myself in Perak. Williamson is probably correct in regarding Krüger's species as not distinct from that of de Selys.

Ranges from Japan to Borneo.

*MACROGOMPHUS ALBARDÆ de Selys.

Macrogomphus albardæ Selys, 4^{me} Addit. Synops. Gomph., loc. cit. pp. 416–418; id., Ann. Mus. Civ. Genova, xxvii. 1889, p. 469; Kirby, Cat. p. 63; Karsch, Entom. Nachr. xvii. 1891, p. 224; Krüger, Stettin. Entom. Zeitg. 1898, p. 300; Williamson, loc. cit. p. 289; Ris, Ann. Soc. Entom. Belg. lv. 1911, p. 238, figs. 7, 8.

Recorded from Sumatra (*Selys*) and Borneo (*Ris*).

MACROGOMPHUS DECEMLINEATUS de Selys.

Macrogomphus decemlineatus Selys, 4^{me} Addit. Synops. Gomph. pp. 418–419; id., Ann. Mus. Civ. Genova, xxvii. 1889, p. 469; Kirby, Cat. p. 63; Krüger, Stettin. Entom. Zeitg. 1898, p. 203; Williamson, loc. cit. p. 289.

2 ♂ from Kuching, May 1896 (Sarawak Museum Collection).

Recorded from Sumatra (*Selys*) and Borneo (*Selys*).

*MACROGOMPHUS QUADRATUS de Selys.

Macrogomphus quadratus Selys, 4^{me} Addit. Synops. Gomph. p. 415; id., Ann. Soc. Entom. Belg. xxvii. 1884, p. x; id., Ann. Mus. Civ. Genova. xxvii. 1889, p. 469; MacLachlan, Ann. Soc. Entom. Belg. xxviii. 1884, p. vii; Förster, Ann. Soc. Entom. Belg. xliii. 1889, p. 65; Kirby, Cat. p. 63; Krüger, Stettin. Entom. Zeitg. 1898, pp. 296–297; Williamson, loc. cit. p. 287.

From Borneo (*Selys*) and Sumatra (*Selys*).

MICROGOMPHUS CHELIFER de Selys.

Microgomphus chelifer Selys, Hagen, Monogr. Gomph. p. 364; Selys, Addit. Synops. Gomph. p. 533; Kirby, Cat. p. 63; Krüger, Stettin. Entom. Zeitg. 1898, p. 302; Laidlaw, Proc. Zool. Soc. Lond. 1902, i. p. 79; Williamson, loc. cit. pp. 295–296, figs. 21, 22.

1 ♂. Saribas, 1910.

A new record for Borneo. Known from Malacca (*Selys*) and Sumatra (*Krüger*).

*LEPTOGOMPHUS SEMPERI de Selys.

Leptogomphus semperi Selys, 4^{me} Addit. Synops. Gomph. pp. 443–444; Martin, Mission Pavie, p. 11 (sep.); Kirby, Cat. p. 70; Williamson, loc. cit. pp. 292–293, fig. 17; Ris, Suppl. Entom. Deutsch., Entom. Mus. no. 1, 1912, p. 69.

Recorded from Borneo (*Martin*), Philippines (*Selys*), Tonkin (*Martin*).

LEPTOGOMPHUS WILLIAMSONI Laidlaw.

Leptogomphus williamsoni Laidlaw, Journ. Str. Br. R. Asiat. Soc. [no. 63] Dec. 1912, p. 94, figs. 1, 2.

This species belongs to section B of the genus as defined by Ris.

It has the basal subcostal nerve of the second series present on all four wings; the hamuli are large and the "Penischale" is small. The upper pair of anal appendages are very similar to those figured by Ris for *L. perforatus* Ris and *L. sauteri* Ris.

It is characterized by the possession of a single row of cells only in the whole anal area, and by the rather striking yellow spot on the dorsum of segment 10 of the abdomen. (For figures of genital appendage of this species see Laidlaw, *loc. cit.*)

The type ♂ is in the British Museum.

[*LEPTOGOMPHUS KELANTANENSIS* (Laidlaw).*†

Leptogomphus kelantanensis Williamson, *loc. cit.* p. 291 (1907).

Gomphus consobrinus Laidlaw (nom. preoccup.), *Proc. Zool. Soc. Lond.* 1902, i. p. 80, pl. v. fig. 5.

Gomphus kelantanensis Laidlaw, *Proc. Zool. Soc. Lond.* 1902, ii. p. 382 (footnote).

This species belongs to section A of the genus, according to Dr. Ris' arrangement. There is no basal postcostal of the second series, the hamuli are small, and the "Penischale" large. The single male captured is fully adult and its sober colouring is excellently shown in Mr. Wilson's figure, where the venational characters are also satisfactorily exhibited (*Proc. Zool. Soc. Lond.* 1902, pl. v. fig. 5).

Like *L. williamsoni*, this species has its anal area composed of a single row of cells. The upper anal appendages are rather small, with a single well-marked but small tooth on their outer side at about the middle of their length; the appendage terminates in a fine upturned point; each extremity of the lower appendage is hooked upwards rather abruptly at its termination.

The type ♂ is in the Zoological Museum of the University of Cambridge.]

BURMAGOMPHUS VERMICULATUS (Martin), subsp. *INSULARIS*, nov. (Pl. I. fig. 2.)

Gomphus vermiculatus Martin, *Mission Pavie*, p. 11 (sep.).

Burmagomphus vermiculatus Williamson (nec Martin?), *loc. cit.* pp. 298-301, figs. 27, 28, 29 (10); (Ris, *Tijdschrift v. Entom.*, Deel lv. 1912, p. 164).

1 ♂.

An interesting addition to the fauna of Borneo. In size it agrees closely with Williamson's specimens from Burnah, in most other respects it appears to approach the individuals described by Martin from Tonkin. I am disposed to believe that Williamson's examples represent a species distinct from the true *B. vermiculatus* of Martin; but cannot be certain on the point without a good supply of material from the two localities.

In any case the present specimen agrees rather with Martin's specimen than with those described by Williamson.

* Not recorded from Borneo.

† [The parentheses around the names of authors placed after scientific names in this paper are used in accordance with Article 23 of the International Rules of Nomenclature. (*Proc. 7th Int. Cong. Boston, 1907*, p. 44 (1912).—EDITOR.)]

The individual here recorded shows well the generic characters tabulated by Williamson. The wing characters are almost identical with those shown in his figure (*loc. cit.* fig. 27). A difference which may be merely individual, but if not, one that I should regard as of specific importance, is that the anal triangle of both hind wings of the Bornean specimen is divided into two cells only, by a cross-nerve running parallel to the long axis of the wing. Williamson's figure might well have been taken from this representative specimen from Borneo excepting for this, for the difference in the number of antenodal and postnodal nerves, and for the fact that in the Burmese specimen figured the area included between Cu_2 and A_1 in the hind wing is a little shorter and broader than in the individual under consideration; and, lastly, for a slight difference evident in the relative size of the pterostigmata.

Details are as follows:—

Length of abdomen 28 mm.

Length of hind wing 28 mm.

Venation:—

$$\begin{array}{rcc} & 13-12 & 9-9 \\ \text{An.n.} & \frac{\quad}{9-8} & ; \text{Pn.n.} \frac{\quad}{8-10} \end{array}$$

Pterostigma a shade longer and narrower than in the type of the genus, covering 4 cells in the front wing.

Head: Anterior surfaces black, with a rectangular yellow mark on either side of the upper lip, and a yellow spot at each angle of the lip; a transverse yellow band along the crest of the frons divided by a fine median line into two lateral halves.

Thorax black above, marked with a yellow mesothoracic half-collar interrupted in the middle line, tapering laterally. A pair of narrow dorsal stripes of the same colour, not reaching to the base of the femora; a very small superior antehumeral spot on either side. Laterally, from immediately behind the humeral suture, the thorax is yellow marked with a black line which rises below at the level of the first lateral suture, includes the stigma, curves backward to join a second black line which follows the course of the second lateral suture, but bifurcates above to enclose a small yellow space.

Abdomen black marked with yellow; 1 with a lateral spot on either side; 2 with a dorsal triangle, its apex directed backwards covering the first two-thirds of the segment, sides including the auricles also yellow; 3-7 each with a fine yellow, basal, transverse mark dorsally, occupying about the first eighth of the length of the segment; 8 entirely black; 9 with the trace of a yellow ring at its apex; 10 entirely black.

Legs black, the first pair of femora yellow on their inner side, the second pair with a small yellow mark on the same surface distally.

Appendages black. The genital structures on 2 are almost identical with those shown in Williamson's figure (Williamson, *loc. cit.* fig. 28 c), the second pair of hamuli not quite so prominent.

Anal appendages relatively shorter, the limbs of the lower one stouter and less divaricate (*loc. cit.* fig. 28, A, B. Cf. also Martin, quoted by Williamson, *loc. cit.* p. 301).

[Ris *loc. cit.* has recently described a species from Java which he refers to this genus under the name *B. jacobsoni*. This species differs from *B. vermiculatus* in the colouring of the thorax, in the shape of the genital hamuli, and of the anal appendages. It is also a little larger.

He is inclined to regard the form described by Williamson as distinct from the true *B. vermiculatus* of Martin.]

The specimen described above is deposited in the British Museum.

HETEROGOMPHUS ICTEROPS Martin, subsp. BORNEENSIS, nov.? (Pl. I. fig. 3.)

Heterogomphus icterops Martin, Mission Pavie, p. 9 (sep.); id., Bull. Mus. d'Hist. Nat. 1902, no. 7, p. 506; Williamson, *loc. cit.* p. 316.

1 ♂. Matang Rd. 28:3:10.

Length of abdomen (without appendages) 51 mm.

Length of hind wing 45 mm.

The cross-nerves on the wings on the right side of the single specimen are highly irregular; it would seem as though that during development those wings had suffered from a "cell-storm" which did not interfere with the general symmetry of the wings nor yet largely with their main structural features, but considerably disturbed the number and arrangement of the cross-nerves, especially on and near the costal spaces.

Martin's description of the species, based on an example in de Selys' collection, from Java, is very brief. Hence, without actually confronting the specimens, it is impossible to say how far the Bornean form here described is distinct.

Venation:—

	16—22!	13—13
An.n.	———	———
	13—15!	12—15

In addition, there are several incomplete antenodals on the right fore wing, and two cross-nerves in the submedian space, whilst there is also a single cross-nerve in the supra-triangle of the hind wing of that side.

The pterostigma has a well-developed brace on all four wings.

Head: With the exception of the vertex and occiput which are very dark brown, and of the eyes which in the dead specimen are brown, the head is light brownish yellow in colour; the *prothorax* is brown, lighter at the sides.

The *thorax* is yellow marked with brown as follows:—A broad humeral band continuous above with the brown of the antealar sinuses and below with a narrow stripe running along the anterior margin of the mesothorax; a broad band runs down along the mid-dorsal carina, narrowing below and just meeting the posterior

margin of the mesothoracic half-collar, but not coalescing with the brown stripe along its anterior border. Laterally, there is a narrow stripe along the second lateral suture continuous over the back.

Legs: Femora red-brown, tibiae and distal parts black.

Abdomen rather pale brown, each segment, excepting the first two and the last two, having a black ring distally. 1, 2 are largely yellow at the sides and have yellow markings dorsally; in 1 this is confined to the posterior half of the segment, except for a very fine line extending forwards to the anterior end of the segment in the mid-dorsal line. In 2 the dorsal yellow colour takes the form of an irregular longitudinal band. On 7 the brown of the anterior three-fifths of the dorsum of the segment carries a square yellow mark. 9, 10 are unmarked, 9 dark brown, 10 lighter. The latter segment is very short, not half the length of 9.

Anal appendages light brown, the extreme points finely tipped with black. In general resembling those of *H. smithi* Selys, long and slender, the upper pair as long as 9, 10 together, the limbs of the lower appendage about four-fifths as long. The upper pair are straight, their tips hooked downwards to a very trifling extent. The limbs of the lower appendage are also straight, except at their apices which have a slight curving upwards, whilst each carries at about one-sixth of its length from the apex a small sharply-pointed spur, directed inwards at a right angle to the axis of the limb.

This large and handsome insect represents a genus new to the fauna of Borneo, and is one of the most interesting of Mr. Moulton's many "finds" amongst the Odonata of the island.

The specimen will be deposited in the British Museum.

Subfamily CHLOROGOMPHINÆ.

In describing the venation of the species of this subfamily, I use the term "anal loop" to indicate the very definite area lying below the cubital space bounded by branches of the anal vein and by $An_1 + Cu_2$. The name is used in the same sense by Needham (Proc. U.S. Nat. Mus. xxvi, p. 733) for *Chlorogomphus*. The loop, as well as the area between Cu_2 and An_1 in the hind wing, seems liable to considerable individual variation in the genus.

I have figured the penis of *Orogomphus dyak* (Pl. I. fig. 7), and would call attention to its close resemblance to that of *Cordulegaster*. The structure of the antennæ is also well worth remark.

Ris has noted the occurrence of tibial ridges in the males of this subfamily (Ris, Coll. Zool. Selys, ix, p. 9, 1909). These ridges, so far as one can judge, are scarcely adaptive structures, and their presence would appear to me to indicate a real if remote relationship to the Corduliinæ.

OROGOMPHUS DYAK Laidlaw. (Pl. I. figs. 4-7.)

Orogomphus dyak Laidlaw, Journ. Straits Branch R. Asiatic Soc. 1910, p. 121 (1911).

♂ ♂.

Venation :—

The triangles of the hind wings have their upper and outer sides subequal, the inner side distinctly shorter, resembling that of the fore wing.

Formula :—

	Anal loop of hind wing.	An.n.	Pn.n.	M.	Cu.	t. (cells).	suprat.
		21—21	11—12	3—3	7—7	1—1	5—5
♂ ₁ (type)...	7—7	18—16	15—15	3—3	6—7	1—1	5—4
		21—24	11—11	3—3	8—6	1—1	5—4
♂ ₂	8—6	16—18	12—13	3—3	7—7	1—1	5—4

The wings have a slightly yellow tinge, most marked when seen with reflected light, between Cu and M₂ proximal to the pterostigma, especially in the specimen marked ♂₂.

Head: Labium brownish yellow, labrum black; rhinarium dark brown, nasus bright lemon-yellow; frons black, but with a fine yellow line along the crest which is surmounted by a number of fine black hairs, not so numerous as in *O. atkinsoni*. Vertex and occiput jet-black. Ocelli and antennæ as in *O. atkinsoni*.

Prothorax black above, the posterior margin edged with yellow, and the same colour on the sides.

Thorax relatively small, black, marked with yellow lines. On either side is a narrow dorsal thoracic stripe, widening a little at its extremities, touching the mesothoracic half-collar below, a little curved with its convexity inwards; followed by a broader antehumeral stripe. There is a narrow stripe laterally on the metepisternum, and the metepimeron is finely edged with yellow; the under surfaces are brownish, and there is a yellow interalar spot and a fine yellow spot on each alar sinus.

Legs black, coxæ and base of under side of femora of the first pair yellow.

Abdomen black, marked with golden yellow as follows:—A fine transverse line at the distal end of 1; the distal half of 2, but this is largely obscured by a broad transverse black band lying within it; the auricles are yellow. There is a very small pair of lateral spots about the middle of 3, and a small terminal transverse spot on the same segment. On 6 there is a terminal ring, occupying about the last one-eighth of the length of the segment.

The anal appendages are black, rather longer than 10. They resemble generally those of *O. splendidus* as figured by Dr. Ris, but differ in detail; the upper pair is much slenderer than in that species and has the ventral teeth much smaller; the lower

appendage is much less deeply cleft and its limbs are pointed, not truncate.

♀ ♀. Matang Rd.

In details of venation these two specimens differ considerably from one another.

Formula:—

	Anal loop (hind wing).	An.n.	Ph.n.	M.	Cu.	t. (cells).	suprat.
A (type) ...	<u>10—10</u>	<u>22—23</u>	<u>12—11</u>	<u>3—3</u>	<u>8—7</u>	<u>2—2</u>	<u>5—6</u>
		19—20	14—14	3—4	9—9	3—3	6—6
B	<u>14—14</u>	<u>22—22</u>	<u>12—10</u>	<u>3—3</u>	<u>8—9</u>	<u>2—2</u>	<u>5—5</u>
		20—20	14—15	4—3	9—9	3—3	6—5

The difference is most marked in the anal area. Not only is the number of cells here greater in specimen B than in A, but there is also a marked difference in the number of cells lying between the fork of Cu_2 : in A these cells lie in two rows, and, excluding the marginal cells, are 9 in number; in B, on the other hand, they are disposed in three rows and number 13 and 11.

As in the males the inner side of the triangle of the hinder wings is the shorter, though in this sex the difference is not very strongly marked.

The type-specimen, A, evidently the more mature, has the wings suffused with a golden-brown tinge throughout; most marked at the bases and apices. The colour is richest about the periphery of the cell, the central part, especially at the apices of the wings, being often distinctly paler. B, the younger specimen, has the wings almost colourless, but with a very faint yellow tinge between the nodus and pterostigma extending down the wing as far as M_2 .

The colouring of the head, thorax, and body scarcely differs from that found in the male.

The following are the principal measurements:—

Length of abdomen: ♂ 53 mm., ♀ 56 mm.

Length of hind wing: ♂ 38 mm., ♀ 42 mm.; breadth ♀ 14 mm.

In both sexes a basal postcostal nerve is present.

Type ♂ & ♀ will be deposited in the British Museum.

OROGOMPHUS SPLENDIDUS de Selys. (Pl. I. fig. 8.)

Orogomphus splendidus Selys, 4^{me} Addition Synops. Gomph. p. 681 (1878); id. Anal. Soc. Españ. Hist. Nat. xi. p. 16 (1882); Kirby, Cat. Odonata, p. 79; Martin, Mission Pavie, p. 14 (sep.) (1904); Williamson, loc. cit. p. 278 (1907); Ris, Suppl. Entom. Deutsch., Ent. Mus. No. 1, 1912, pp. 77, 79, fig. 15 a, b, Taf. iii. figs. 1–6, Taf. v. fig. 5.

Mr. Moulton has forwarded me two female specimens presumably belonging to one and the same species though showing

some rather marked differences in venation. These two specimens are, I believe, to be referred to *O. splendidus* de Selys. It is evident from Ris' study of the venation of three males belonging to this species, that there is a considerable amount of individual variation to be looked for, and the agreement between them and de Selys' type is close in other respects.

One of the specimens has been returned to the Sarawak Museum, and unfortunately I did not before returning it make full notes of the venational formula for both pairs of wings.

	Anal loop (hind wing).	An.n.	Pn.n.	M.	Cu.	t. (cells).	suprat.
1.	—	—26	—13	—2	—9	—3	—5
	—20	—19	—16	—3	—8	—3	—4
2.	—	26—25	14—13	3—2	8—8	2—2	5—5
	13—14	20—18	17—18	2—2	8—8	3—3	5—4
(de Selys' type.)	—	23—25	14	3	6—7	3	5—6
	—	—	—	—	—	—	—

The most marked difference between Mr. Moulton's specimens is in the anal loop. In Ris' photograph of the type ♂ from Kosempo that area contains 19 cells.

Further, in Moulton's specimens in 1. there are only 2 rows of cells in the space between Cu_2 and A, almost to the margin of the wing, whilst in 2. there are on the right side 4 rows and on the left 6 rows; in the type male there appear to be 6 rows.

The wings of the Bornean specimens are coloured as follows:—Base and apices of wings suffused with bright golden brown, on the fore wing reaching to the inner angle of the triangle, and on the hind wing one cell beyond the arcus; at the apices the colour begins rather nearer to the pterostigma than to the nodus, and is fainter on the anal margin of the wing.

The basal postcostal nerve is absent in these female specimens; it is present in the male figured by Dr. Ris.

The colouring of the head, thorax, and body is as described for the male.

The chief measurements are:—

Length of abdomen circa 56 mm.

Length of hind wing 48 mm.; breadth 17.5 mm.

[*Orogomphus atkinsoni* de Selys.*

Orogomphus atkinsoni Selys, 4^{me} Add. Synops. Gomph. p. 682 (1878); Kirby, Cat. p. 79; Selys, Ann. Mus. Civ. Genova, 2. x. (p. 49 sep.) (1891); Williamson, loc. cit. p. 278, figs. 5, 6 (1907).

1 ♀, Bhowali.

(Indian Forest Research Institute per Dr. Imms.)

* Not recorded from Borneo.

The following is an account of the single specimen of this species that I have been able to examine :—

Venation: The triangle of the hind wing, as in the specimen figured by Williamson from the de Selys collection, has its upper and inner sides subequal, distinctly shorter than is the outer side. The male, judging from Williamson's figure, has the inner side distinctly shorter than the other two sides, so that the apex of the triangle is at its outer angle.

The triangles of the hind wings in my specimen are bisected in each wing by a nerve running from its inner angle to the middle of the outer side, whilst in de Selys' specimen, on the left side at any rate, the triangle is divided into 3 cells. Otherwise the venation agrees in detail between the two specimens. There is no basal subcostal nerve.

The wing-formula of the two female examples is as follows :—

	Anal loop of hind wing.	An.n.	Pn.n.	M.	Cu.	t. (cells).	suprat.
Bhowali, Kumaon.....	<u>19—19</u>	<u>19—19</u>	<u>9—10</u>	<u>1—1</u>	<u>6—7</u>	<u>2—2</u>	<u>3—3</u>
	10—10	14—13	12—12	1—1	6—6	2—2	3—3
Bengal. Coll. Selys. (From Williamson's figure.)	<u>19—</u>	<u>19—</u>	<u>12—</u>	<u>1—</u>	<u>7—</u>	<u>3—</u>	<u>3</u>
	12—	15—	13 (?)	1—	8—	3—	3 (? 4)

The wing-formula of the male is

Bengal. Coll. Selys. } (From Williamson's figure.)	20—	10—	1—	7—	2—	3—
	9—	13—	14—	1—	5—	2—

In the specimen from Bhowali the extreme base of both pairs of wings has a golden tinge, this does not extend so far as the first cross-nerves.

Head: Labium dull brown. Labrum brown edged with black. Rhinarium dark brown; nasus and frons brownish yellow, the frons at its vertex carries a line of fine black hairs, and is as high as the summit of the occiput. In front it is rather flattened. Vertex black; the ocelli lie in a slightly curved line, the median one being placed a little in advance of the lateral pair.

The antennæ have the second joint relatively very large and stout, cylindrical in shape, and equal in length to the distal part of the organ which consists of five or six slender joints. The large brown eyes meet at a point; and the occiput is small, dark brown in colour, with a fringe of fine yellow hairs.

The *prothorax* is small, dark brown above, its posterior margin lemon-yellow.

The *thorax* is relatively small, black, and thickly covered with silky brown hairs; there is a pair of dorsal humeral stripes, rather wedge-shaped, with their apices directed forwards, not quite touching the margin, of a bright lemon-yellow colour. Two broad bands of the same colour lie on either side of the thorax,

the first on the mesepimeron, the second, the broader, on the metepimeron; the under surfaces are brown, and there is a yellow spot on the interalar sinus.

The *legs* are black, the coxæ and base of under surface of the first pair are lemon-yellow.

Abdomen: Segments 1, 2, 3 and 5, 6, 7 a little dilated. Black with golden-yellow markings as follows:—A fine transverse band at the distal end of the dorsum of 1. The terminal half of 2, but this band carries a black median dorsal spot, which has rather the shape of a three-pointed ivy-leaf directed backwards, the yellow band is also incomplete below. 3, 4, 5 with a pair of lateral spots at their middle, and a terminal half-circle, interrupted by the mid-dorsal carina. 6, 7, 8, 9 with the terminal half-circle only.

Measurements of specimen from Bhowali:—

Length of abdomen 57 mm.; hind wing 42.5 mm.

Length of pterostigma 3 mm.; width of head 9 mm.

Breadth of wing 15 mm.]

NOTE.—I have omitted from the list *Macrogomphus abnormis* de Selys as its provenance is doubtful.

EXPLANATION OF THE PLATE.

- Fig. 1. *Ictinus acutus*, sp. n. Superior anal appendages of male, seen from above.
 2. *Burmagomphus vermiculatus* (Martin), *insularis* subsp. n. Thoracic colour pattern (diagrammatic).
 3. *Heterogomphus icterops* Martin, *borneensis* subsp. n.?
 4. *Orogomphus dyak* Laidlaw. ♂, wings of left side.
 5. " " " ♀, wings of left side.
 6. " " " ♂, anal appendages.
 7. " " " ♂, penis and vesicle.
 8. *Orogomphus splendidus* de Selys. ♀, wings of left side.

(For the photographs from which figs. 3, 4, 5, and 8 are reproduced I am indebted to the kindness of Messrs. F. W. & H. Campion.)

5. Note on an imperfectly developed specimen of the Sea-Urchin (*Echinus esculentus*). By H. C. CHADWICK, A.L.S.*

[Received October 30, 1913 : Read February 17, 1914.]

(Text-figures 1-4.)

The subject of this note was collected and handed to me for description by Prof. W. J. Dakin, who found it upon the ruined breakwater at Port Erin during the autumn of 1912. Prof. Dakin's attention was attracted to it by two well-marked depressions in the test, which were evident while the animal was living and covered with spines. The depressions are in inter-ambulacra 1 and 4; and, denuded of its spines, the test presents the appearance of a lump of plastic material which has been pinched by the thumb and forefinger. The spines of the entire test were distinctly larger and more densely crowded than those of a normal specimen of the same size from the same locality.

The apical system presents two abnormalities. Genital 4 is of normal shape, but consists of two distinct plates united by suture. Two closely approximated but distinct pores occupy the position of the normal one on genital 1.

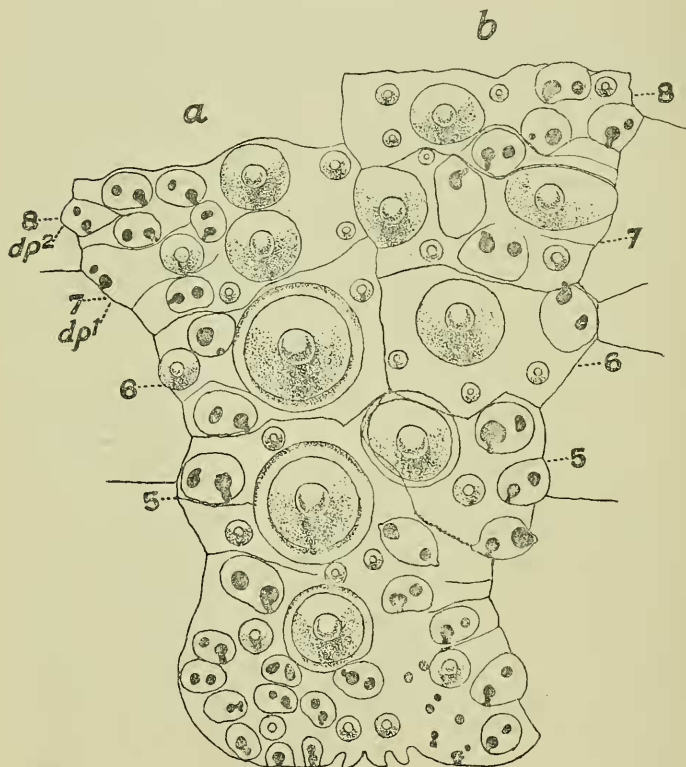
As shown in text-fig. 1, the composition of the first seven or eight plates of both series in ambulacrum II is irregular, that of the first four especially so. The plates numbered 5 and 6 respectively in series *a* appear to be composed of two primaries, the adoral of number 5 being imperforate. In the case of the elements which I have interpreted as plates 7 and 8, I conclude that dp^1 is the demi-plate of plate 7; and but for the complete reversal of the position of the pores of the pair borne by the small plate lying between it and the aboral primary of plate 6, this might have been regarded as the adoral primary of the same plate. dp^2 is probably the demi-plate of plate 8. The first recognisable plate in series *b* is most probably number 5. Number 6 is clearly defined, but there are no traces of sutures to indicate its composition. The position of the single pore-pair suggests that it is that of a demi-plate. Number 7 appears to consist of two primaries without a demi-plate. The peripode of the element which I have interpreted as the aboral primary lies at right angles to the normal position and encloses only one pore. It is, however, possible that the pore-pair which lies aborally and to the right of this may be an element of plate 7, and that the large ellipsoid tubercle occupies the position of the pore-pair of the demi-plate. Should this view be correct, the next plate, number 8, is practically a normal one.

Proceeding now in the direction of the apical pole, all the

* Communicated by Dr. F. A. BATHER, F.R.S., F.Z.S.

plates of series *a* are normal until number 46 is reached. Then follow a series which, regarded from their inner, tuberculate ends, apparently number seven plates, and which exhibit striking irregularity of composition (text-fig. 2). It may be that the two numbered 47 and 47 *a* respectively compose one but slightly imperfect plate, that portion of the suture which traverses the large tubercle, and is represented by the dotted line, being

Text-figure 1.

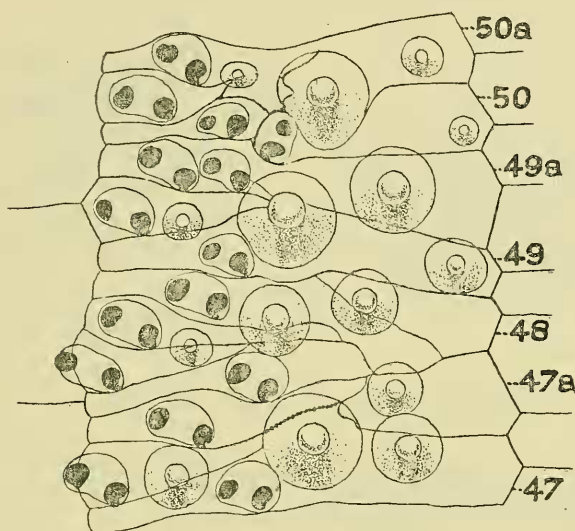


Oral end of ambulacrum II. The Arabic numerals indicate the numbers of the plates, reckoned from the peristome. *a* and *b*, series in ambulacral area.

obscure. Number 48 consists of five elements, none of which ranks among the primaries, while only one is imperforate. The next two plates are numbered 49 and 49 *a* respectively, on the assumption, which the positions of three of the pore-pairs supports, that they represent one ordinary plate. The appearance of the next plates, numbered 50 and 50 *a* respectively, suggests that they also

represent one ordinary plate. The presence of a fourth pore-pair in this and the preceding plate is difficult to account for, except on the assumption that both represent small interpolated elements.

Text-figure 2.

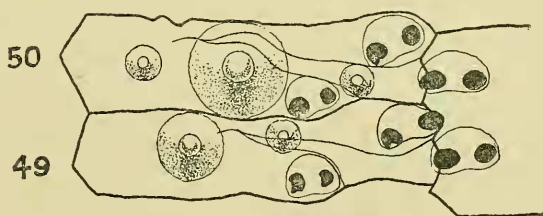


Abnormal plates in series *a* of ambulacrum II.

For explanation of lettering, see text-fig. 1.

In series *b* of ambulacrum III (text-fig. 3) plates 49 and 50, while of normal composition, are exceptional in that the pore-

Text-figure 3.

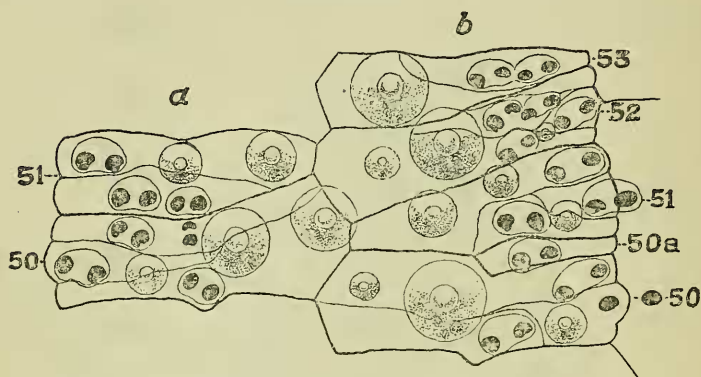


Abnormal plates in series *b* of ambulacrum III.

pairs of their respective demi-plates are almost completely outside the limits of the plate, and perforate the adjoining interambulacral plate.

Similar irregularities, though not so well marked, occur in plates 50 and 51 of series *b* of ambulacrum IV (text-fig. 4). In this ambulacrum the presence of a fourth pore-pair in plate 50

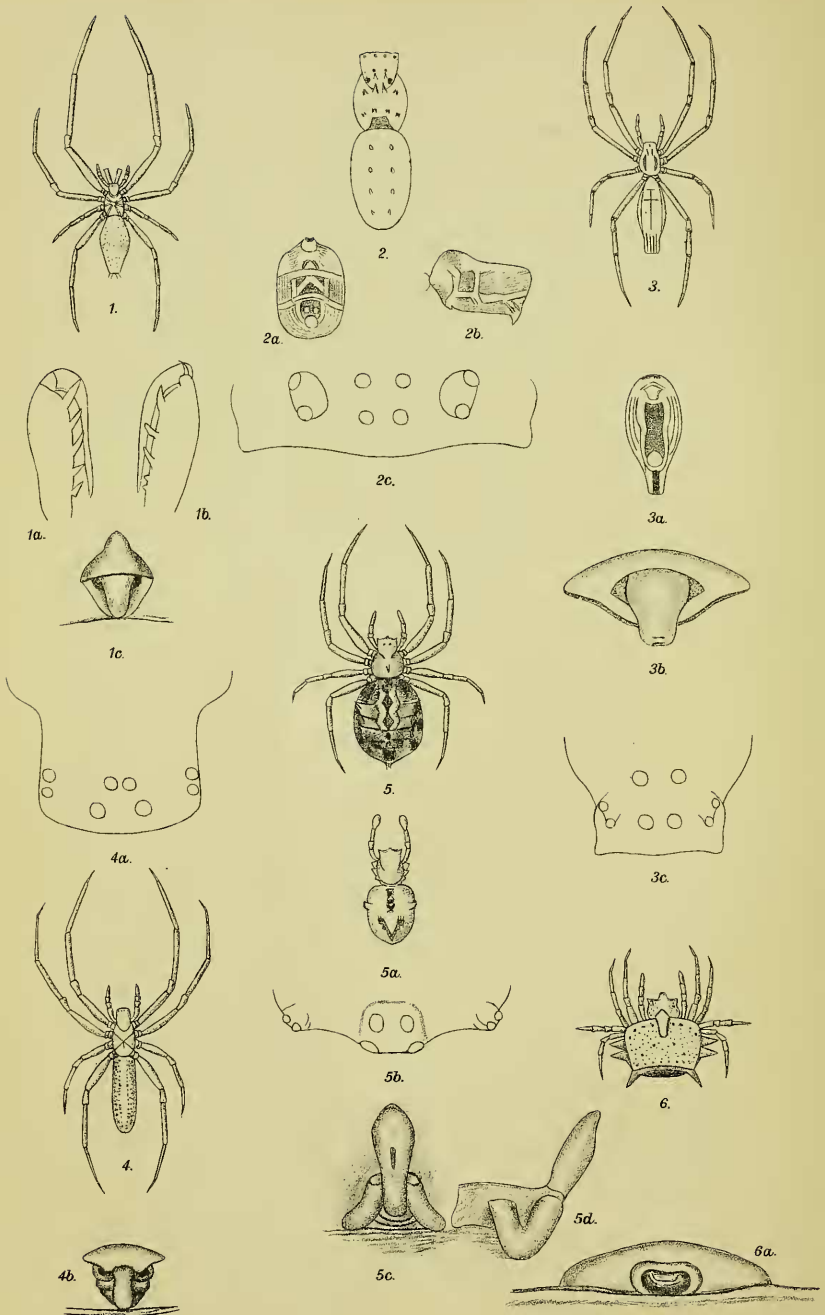
Text-figure 4.



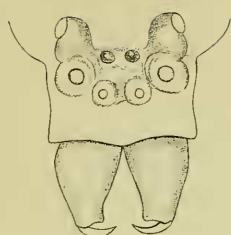
Abnormal plates in series *a* and *b* of ambulacrum IV.

in series *a* and plate 52 in series *b* again suggests the interpolation of small and obscure elements. No. 52 in series *b* undoubtedly has an interpolated demi-plate.

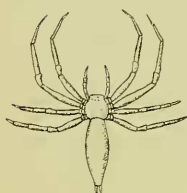








7a.



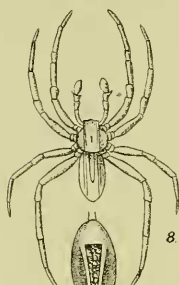
7.



7b.

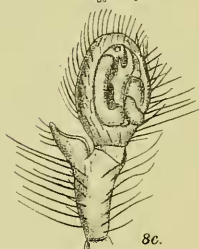


8a.

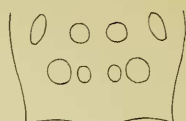


8

8b



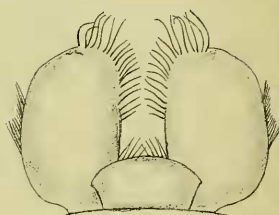
8c.



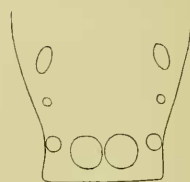
9a.



9.



9b.



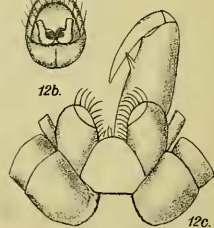
12a.



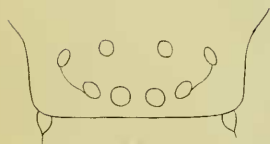
12.



12b.



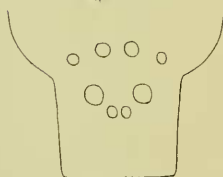
12c.



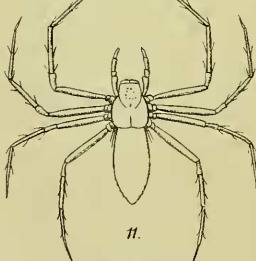
10a.



10.



11a.



11.



11b



10b.



10c.

6. Spiders from the Montebello Islands.

By H. R. Hogg, M.A., F.Z.S.

[Received December 22, 1913 : Read March 3, 1914.]

(Plates I.-II.*)

INDEX.	Page
<i>Tetragnatha angulata</i> , sp. n.	70
<i>Nephila venosa</i>	71
<i>Nephila meridionalis</i> , var. <i>hermitis</i> , nov.	72
<i>Argiope trifasciata</i>	73
<i>Argiope haynesi</i> , sp. n.	73
<i>Larinia montagui</i> , sp. n.	75
<i>Araneus reversus</i> , sp. n.	77
<i>Gasteracantha minax</i>	79
<i>Gasteracantha minax</i> , var. <i>lugubris</i>	79
<i>Gasteracantha minax</i> , var. <i>astrigera</i>	79
<i>Gasteracantha minax</i> , var. <i>hermitis</i> , nov.	80
<i>Dieta isolata</i> , sp. n.	80
<i>Miturga parva</i> , sp. n.	82
<i>Olios calligaster</i>	84
<i>Olios hermitis</i> , sp. n.	85
<i>Montebello tenuis</i> , gen. et sp. n.	86
<i>Lycosa clara</i>	88
<i>Oxyopes</i> ? <i>mundulus</i>	88
<i>Peucetia margaritata</i> , sp. n.	89
<i>Marpissa ridens</i> , sp. n.	90

The collection of Spiders hereunder described was made partly by Mr. P. D. Montague, and partly by Mr. T. H. Haynes. By the kindness of these gentlemen they have been placed in my hands.

The Montebello group is situated on the N.W. coast of Australia, off the Port of Onslow, W. Australia, the largest, Hermite Island, being 90 miles from the mainland, in lat. 20° 30' S., long. 145° 15' W.

Mr. Montague visited the islands for the purpose of collecting specimens of the fauna, and Mr. Haynes lived on Hermite Island for about three years, until driven off by a hurricane which destroyed his hut and a larger collection which he had been good enough to make at my request.

Mr. Haynes informs me that the soil consists of sandstone-rock, similar to that on the mainland, of which therefore the islands were probably part, and the S.E. winds prevailing for the six winter months blow off the land.

It will be noticed that by far the larger number, both of species and specimens, are of the family Argiopidae, with a small sprinkling of Lycosidae, Thomisidae, Clubionidae, Oxyopidae, and Attidae.

* For explanation of the Plates see p. 92.

Notable absentees are *Delena cancerides* Walck., and *Latrodectus hasseltii* Thor., found generally in every part of Australia, but no specimens have been brought from here.

Family ARGIOPIDÆ.

Subfamily TETRAGNATHINÆ.

Group TETRAGNATHÆ.

Genus TETRAGNATHA Latreille.

TETRAGNATHA ANGULATA, sp. n. (Pl. I. fig. 1.)

A single specimen (P. D. M.).

Female. The cephalothorax is greyish yellow, with broad darker depressions separating the cephalic from the thoracic part and broad dark grey radial lines from the margin of the cephalothorax to a transverse broad oval depression, one-third of the distance between the end of the cephalic part and the rear end of the thoracic, also dark grey round the margin of the thoracic part; it is sparsely covered with short, fine, white hairs. The eyes are yellow on black ground. Mandibles yellow tinged with dark grey at the sides, and with a few white hairs. Fangs yellow-brown. Sternum rather dark yellow-brown. The lower part of the lip the same. The upper margin of the lip and the maxillæ are bright yellow with light brown fringes. Legs and palpi pale yellow with brown spines, rising from brown patches. The abdomen above is greyish yellow, with a mottling of darker grey, pale yellow below with a broken median darker yellow stripe.

The cephalothorax is twice as long as broad, convex, narrowed in front, rounded at the sides, and slightly hollowed at the rear end.

The rear row of eyes is straight, or slightly recurved when seen from above, of equal size, the median $2\frac{1}{2}$ diameters apart and 3 diameters from their laterals, which are their diameter away from the front laterals. The front row, more strongly recurved, has the laterals only half the diameter of the rear, lying on the same tubercle therewith. The front median are rather larger than the rear, $1\frac{1}{2}$ times their diameter apart, and the same from the rear, so that they form a quadrilateral, broadest posteriorly; they are one-half their diameter from the margin of the clypeus, which overhangs the insertion of the mandibles. These are divergent, projecting forward, kneed at the base. On the outer margin of the falx-sheath are five teeth at equal intervals apart, the upper one situated at the anterior inner corner is the largest, the others diminishing in order of sequence. On the under side the upper one is similarly placed, followed by two rather smaller, at intervals of their length, and then three quite small close together.

The maxillæ are rather divergent, truncate, and broadest

anteriorly, three times the height of the lip, which is broader than long, rounded in front, straight at the sides with the upper margin clearly protrudent. The sternum is shield-shaped, $1\frac{1}{2}$ times as long as broad; from its greatest breadth between the second pair of coxæ it narrows slightly anteriorly and posteriorly to a point between the not quite contiguous rear coxæ. The legs are long and thin, the metatarsi and tarsi tapering to a very fine point. The abdomen is twice as long as broad, widening from the base to halfway of its length, whence it rather suddenly narrows and tapers to the spinnerets. The epigyne is dome-shaped on the upper half, overhanging two oval hollows, one each side of a median broad ridge.

This species is rather near L. Koch's *T. gemmata* from Port Mackay, but is smaller; the first pair of legs not so long compared with the second, and the mandible on the upper side is without the large tooth near the middle of the anterior edge; the coloration is much lighter, and there are brown spots on the legs.

The measurements (in millimetres) are as follows:—

		Long.	Bread.			
Cephalothorax...		2	1			
Abdomen.....		4	2			
Mandibles		$1\frac{1}{4}$				
		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.	
Legs	1.	$\frac{3}{8}$	4	5	4	= $13\frac{3}{8}$
	2.	$\frac{1}{4}$	3	3	3	= $9\frac{1}{4}$
	3	$\frac{1}{4}$	$1\frac{1}{2}$	1	$1\frac{1}{2}$	= $4\frac{1}{4}$
	4.	$\frac{3}{8}$	3	$2\frac{1}{2}$	3	= $8\frac{7}{8}$
Palpi		$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{8}$	= $1\frac{1}{2}$

Subfamily NEPHILINÆ.

Group NEPHILEÆ.

Genus NEPHILA Leach.

NEPHILA VENOSA L. Koch.

8 females (2 non-adult). P. D. Montague.

Hab. (sec. *Rainbow*). Polynesia, New Guinea, Torres Straits, Queensland, N. S. Wales. Victoria and S. Australia (*H. R. H.*).

In these specimens the eyes of the rear row are clearly smaller than those of the front row, whereas in L. Koch's description they are of the same size. This is also the case in my specimens from S. Australia. The longitudinal lines on the rear end of the abdomen are also absent, but the specimens agree in other respects; and I see no reason for making them a local variety, which they might be said to be if only found on this particular island.

NEPHILA MERIDIONALIS Hogg, var. *HERMITIS* nov. (Pl. I. fig. 2.)

Trans. Royal Soc. of S. Australia, vol. xxxiv. 1910, p. 59*.

4 females, T. H. 10 females (6 non-adult), P. D. M.

These correspond in almost every particular with my *N. meridionalis* from Kangaroo Island, S. Australia.

They differ, however, in having the distance between the rear row of median eyes rather greater than that between the front median instead of the same; in the clypeus $1\frac{1}{2}$ times as wide as the distance between the front median eyes instead of equal to it; and the pale lines forming the pattern on the under side of the abdomen much finer. There are also two small black spots behind the eyes and two more on the margin of the cephalic part. I have therefore made it a new variety: *hermitis*.

The measurements (in millimetres) are as follows:—

		Long.	Broad.				
Cephalothorax...		12	{ 6 in front. 8				
Abdomen.....		14					
Mandibles		5	9				
				Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.
						4 & 11	
Legs	1.	$2\frac{1}{2}$	17	15	21	=	$55\frac{1}{2}$
	2.	$2\frac{1}{2}$	15	13	19	=	$49\frac{1}{2}$
	3.	$1\frac{1}{2}$	9	6	$9\frac{1}{2}$	=	26
	4.	2	14	10	$14\frac{1}{2}$	=	$40\frac{1}{2}$
Palpi	1	4	4	3	=		12

Tibia longer than patella.

Another specimen measures:—

		Long.	Broad.				
Cephalothorax...		10	{ 5 in front. $7\frac{1}{2}$				
Abdomen.....		13					
Mandibles		$4\frac{1}{2}$					
				Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.
Legs	1.	$2\frac{1}{2}$	16	15	21	=	$54\frac{1}{2}$
	2.	$2\frac{1}{2}$	15	13	19	=	$49\frac{1}{2}$
	3.	2	9	7	10	=	28
	4.	$2\frac{1}{2}$	14	10	15	=	$41\frac{1}{2}$
Palpi	1	4	4	4	=		13

Differing very slightly from the original type-specimen.

Another, with a cephalothorax 9×7 mm., has the abdomen 20×14 mm., apparently full of eggs.

* The length of the cephalothorax in my original description is misprinted $14\frac{1}{2}$ for $10\frac{1}{2}$ millimetres.

Subfamily ARGIOPINÆ.

Group ARGIOPEÆ.

Genus ARGIOPE Aud.

ARGIOPE TRIFASCIATA Forskål.

13 females, P. D. M. 3, T. H.

Widely spread over Northern Australia, the Pacific Islands, and many other tropical and subtropical parts of the world.

ARGIOPE HAYNESI, sp. n. (Pl. I. fig. 3.)

This species, of which Mr. Haynes sent 10 females, is closely related to L. Koch's *A. protensa* and *A. syrmatica*, though it differs from them both more than they do from one another, and I have therefore named it as new.

The cephalothorax is yellowish grey, thickly covered with smooth silvery grey hairs all over the thoracic part, and in a median longitudinal area between the eyes and at the sides of the thoracic part the darker under coloration shows through, but there are no definite dark longitudinal lines as in *protensa* and *syrmatica*.

The mandibles are dark grey at the base and on the outer sides, rather bright yellow on the inner and anterior portions. The fangs red-brown at base and pale red forward. The lip and maxillæ are bright yellow on the upper half, brown below. The sternum is black-brown, with fine downlying grey hairs at the sides, and a thickly haired yellowish-white median area reaching the whole length.

The abdomen is silvery white with fine white hairs on the upper side; a narrow black longitudinal line, running from the base to rather more than halfway, with two transverse lines at the upper end, like a Russian cross. There are no longitudinal lines at the posterior end. The base of the under side is yellow at the sides and dark grey* in the middle. The dark area is continued in a broad median stripe to the spinnerets, bordered on each side by a white network-patterned area, which passes behind the spinnerets, the dark stripe being continued to the posterior end, as in *A. protensa*, but not in *A. syrmatica*. The sides are dark grey with pale yellow longitudinal lines.

The legs are darkish yellow, with long brown spines and grey hairs. The anterior half of the metatarsus and the whole of the tarsus of all legs have short brown bristly hairs. The front of the patella and base of the tibia is dark brown. Near the anterior end of the tibia is a brown ring, and the anterior end of same and base of metatarsus are likewise covered by a brown spot. The under side of femur 1 is dark grey.

The cephalothorax, one-third longer than broad, is rounded at the sides, the cephalic part, narrow and short, being divided by well-marked depressions from the thoracic. It does not reach to the median fovea, which is short and recurved. The whole

area is rather flat and covered with particularly smooth long hairs all lying longitudinally.

The front row of eyes is straight, the median pair their diameter apart and $1\frac{1}{2}$ times the same distance from the laterals, which are only half their diameter. These are also their diameter from the rear laterals, the diameter of the latter being half as large again, and farther away, sideways, by the breadth of the front laterals. The rear median are the same size as the front median, two diameters therefrom and $1\frac{1}{2}$ diameters from one another. Therefore they form with their laterals a strongly procurved row.

The mandibles are short and conical, only slightly kneed at the base and divergent at the anterior end. The fangs are slightly curved and rather long. On the upper part of the outer margin of the falx-sheath is one long tooth between two shorter, and on the inner in the same position three also, the lowest being the largest.

The maxillæ are convex, as long as broad, obtusely arched on the upper edge and rounded at the back. The lip is broader than long, curved to an obtuse angle in front, where it is very convex, with a short narrower lower stem.

The sternum is shield-shaped, scoloped at the sides, half as long again as broad; opposite the second and third coxæ the median area is projected into high round protuberances, and at the posterior end is a similar but still larger oval knob. The hair is downlying, finer at the sides than in the middle streak, and there are a few long bristles at the anterior end.

The abdomen is $2\frac{1}{2}$ times as long as its breadth in the middle, whence it tapers to a narrow rounded point at each end. On the under side the base is less constricted and more rounded off, the sides are straighter until beyond the spinnerets, where it is suddenly narrowed into a stunted tail. On the back are four pairs of muscle-spots.

The epigyne is formed in the same unique fashion as in *A. protensa* and *A. symatica*, a chitinous cushion-like pear-shaped projection, broadest at the base and having a blunt oval fore end, standing straight up. The basal end is about one-third of the whole breadth of the abdomen at that part.

The legs are rather long and very fine in the anterior joints, the tibia broadened out and flattened at the anterior end, and the trochanter of the fourth pair nearly as long as the coxæ.

The femoral joint of the palpi is strongly incurved, and broadest at the anterior end. The tibia is twice as long as the patella, and the metatarsal joint is covered with long bristly hairs.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	4	$\left\{ \begin{array}{l} 1\frac{1}{4} \text{ in front.} \\ 3 \end{array} \right.$
Abdomen.....	10	4
Mandibles	$1\frac{1}{4}$	

		Coxae.	Tr. & fem.	Pat. & tib.	Metat. & tars.	
Legs	1.	1	7	6 $\frac{1}{2}$	8 $\frac{1}{2}$	= 23
	2.	1	7	6	8	= 22
	3.	$\frac{3}{4}$	4 $\frac{1}{2}$	3	4 $\frac{1}{2}$	= 12 $\frac{3}{4}$
	4.	$\frac{3}{4}$	7	5	7	= 19 $\frac{3}{4}$
Palpi		$\frac{1}{2}$	2	1 $\frac{1}{4}$	1 $\frac{1}{2}$	= 5 $\frac{1}{4}$

The obvious difference between this species and *A. protensa* and *A. symmatica*, which latter are very much alike, is the shortened tail, the absence of the dark longitudinal markings on the cephalothorax and of the longitudinal markings on the posterior end of the upper side of the abdomen, almost every other point being the same or very slightly modified in the three species.

In the somewhat allied genus, *Arachnura* Vins., several species have been constituted on the differences of the knobs at the end of their tails and of their shoulder-humps. Oftentimes these differences are seen in spiders of the same group of webs, and the spiders are possibly all derived from the same batch of eggs. I am not satisfied that this does not occur in the above species, the two first named being both described from the same locality, Port Mackay, in Queensland. The differences between them, if any, are very trifling.

Group MANGOREÆ.

Genus LARINIA Simon.

LARINIA MONTAGUI, sp. n. (Pl. I. fig. 4.)

2 females, P. D. M. 1 female, T. H.

Cephalothorax pale yellow, with a slightly darker median longitudinal streak and thinly spread white hairs. Mandibles the same, with pale yellow-brown fangs. Maxillæ and upper half of lip pale yellow, but base of latter light brown. Sternum pale yellow in median area, with light yellow-brown along the sides and at the lower end. Legs and palpi similar pale yellow, with fine white hairs, light brown spines on brown roots, and brown bristles on tarsus and metatarsus. On femur 1 the brown spots are much more numerous than elsewhere.

The abdomen above is pale yellow with white hairs and white upstanding bristles, but mottled with darker brown in patches, giving the whole a uniform dark appearance. On the under side it is a network of paler and darker yellow. The spinnerets are brighter yellow, and the epigyne brown with yellow in the hollows and an oblong grey area behind it.

The cephalothorax is moderately convex, twice as long as broad and one-half of its greatest breadth across the eye-area. The sides of the cephalic part are straight, those of the thoracic

rounded and there are no depressions separating the two; a longitudinal fovea reaches into the rear slope.

The rear row of eyes is slightly recurved and stretches quite across the cephalic part. The median pair are less than one-third of their diameter apart and four times their diameter from the side eyes, which are rather more than half the same diameter across. The front median are one-eighth wider than the rear median, twice their diameter apart, and $2\frac{1}{2}$ times the same from the rear, thus forming a trapezium twice as wide in front as posteriorly and slightly longer than broad. In a lateral direction they are the same distance from the side eyes as from the rear median. The front side eyes are the same size as the rear side, but half their diameter away, and the front and rear are each on a small separate tubercle. The clypeus is $1\frac{1}{2}$ times the width of one of the front median eyes.

The mandibles are conical, kneed at the base, smooth and shiny. There are two teeth on the outer falx-margin, the anterior twice as long as the lower one; three on the inner margin.

The maxillæ are convex and nearly square. The lip has a short, straight-sided base, the longer and very convex upper part curving to an obtusely angled point.

The sternum is slightly convex, twice as long as broad, shield-shaped, hollowed in front, almost straight at the sides, and narrows rather suddenly to a point, which does not go between the contiguous rear coxæ.

The abdomen is oval, $2\frac{1}{2}$ times as long as broad; it is sparsely covered with fine downlying hair and has upstanding spinous bristles on the upper side.

The legs are thin and tapering, rather profusely covered with small brown spots, from which spring long upstanding spines and bristles on the patellar, tibial, and metatarsal joints and under side of femoral. Bristles only on the tarsal joint.

The palpi have the femoral joint incurved, the patella one-half as long as the tibia, and long spinous bristles on the latter.

The measurements (in millimetres) are as follows:—

		Long.	Broad.			
Cephalothorax...		3	{ 1 in front. 1 $\frac{1}{2}$			
Abdomen.....		5			2	
Mandibles		1 $\frac{1}{4}$				
		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.	
Legs	1.	1	3 $\frac{1}{2}$	4 $\frac{1}{2}$	4 $\frac{1}{2}$	= 13 $\frac{1}{2}$
	2.	$\frac{3}{4}$	3	4	4	= 11 $\frac{3}{4}$
	3.	$\frac{1}{2}$	2	2 $\frac{1}{4}$	1 $\frac{3}{4}$	= 6 $\frac{1}{2}$
	4.	$\frac{3}{4}$	3	3 $\frac{1}{2}$	3 $\frac{1}{2}$	= 10 $\frac{3}{4}$
Palpi		$\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{3}{4}$	= 2 $\frac{3}{4}$

Of L. Koch's two species, *L. phthisica* and *L. tabida*, this species more nearly resembles the former, but is two-thirds smaller and much brighter in colouring. The rear median eyes are larger

than the laterals instead of the same size, and the row recurved from above instead of straight; the clypeus broader. The abdomen also is broader in comparison with its length, and there are only two teeth on the outer falx-sheath (one quite long) instead of four small ones. The epigyne also differs from *L. Koch's* drawing.

The colouring is very close to Dr. Kulczycki's *L. vicina*, from New Guinea, but this species is smaller: the epigyne differs; the rear middle eyes are farther apart; the mandibles longer, two and three teeth respectively, instead of four, on each margin; spots on first pair of legs instead of none; no spots on the back instead of six pairs. The abdomen is also wider in proportion to length.

L. montagui is also very close in most respects to Von Keyserling's *Larinia (Epeira) talipedata*, but in the latter the rear median eyes are as large as the front median, and twice their diameter apart, instead of close together.

This species differs in many points from M. Simon's *L. eburneiventris*, from S.W. Australia.

Group ARANEÆ.

Genus ARANEUS Clerck.

ARANEUS REVERSUS, sp. n. (Pl. I. fig. 5.)

This spider belongs to *L. Koch's* and E. Simon's first series, with shoulder-humps, the abdomen rounded in front and obtusely pointed at the rear.

The cephalothorax, mandibles, and sternum are black-brown with long coarse white hair and white spinous bristles.

The lip and maxillæ are black-brown with wide greyish-yellow margins and red-brown fringes.

The coxæ and femoral joints of the legs and palpi are dark dingy yellow-brown, the patella and tibia nearly black-brown, thickly covered with white hair and numerous spines brown just at the base, but white from there to the point. The metatarsus and tarsus dark dingy yellow-brown with white hair on the basal half of the former, but brown bristles and yellow spines on the anterior half and on the tarsus.

The upper side of the abdomen is at the base yellow mottled with brown spots. Running from this to about halfway down the back is a black-brown median stripe, bordered with yellow and scoloped at the edges into three divisions, and each side of this is a black transverse streak, separated from it by a short longitudinal yellow streak, reaching to the shoulder-humps. From each of these a dark brown scoloped line runs along the side, meeting at the rear end. The latter enclose another scoloped triangular area of brown and yellow intermixed, the straight upper side touching the end of the anterior median stripe. The front part is thickly set with upstanding white spines on brown bases. On the under side a pale

yellow shield pattern, mottled with brown spots, reaches from the genital fold to the spinnerets, with two dark brown longitudinal spots thereon, the basal area being all brown. The spinnerets are black-brown, the epigyne yellow-brown. There is a pair of small brown conical protuberances, one on each side of the breathing-slits. On the sides are vertical black-brown stripes on a dingy yellow ground.

The cephalothorax is one-fifth longer than broad, straight in front, where it is not quite one-half its greatest breadth, convex, rounded at the sides, thickly covered with forward-pointing long coarse hair and upstanding bristles, but bare on the rear slope.

The median quadrangle of eyes is on a somewhat low protuberance lying on the front slope. The rear row is straight, the median their diameter apart, the same distance from the front row, and six diameters from their respective laterals. The front median pair are $1\frac{1}{2}$ times the diameter of the rear and that distance apart. The clypeus is the breadth of one of them. The side eyes are equal in size on a common raised prominence, not much smaller than the rear median, almost touching one another, the front one lying just below and by the distance of its diameter nearer the centre eyes than its upper companion.

The mandibles are broad, conical, kneed at the base, somewhat divergent, and as long as the front of the cephalothorax is broad. They are furnished with bristly hairs for one-third of the distance from the base and on the inner edges, the remainder being smooth. The fangs are stout and not much curved. On the outer margin of the falcis-sheath are three stout teeth near the base. I could not see those on the inner margin.

The maxillæ are nearly triangular, straight on the inner side and front edge, with rounded back and corners. They are as high as the greatest breadth, which is at the front margin. The lip is convex, broader than long, rounded in front, and less than half the length of the maxillæ.

The sternum is convex, shield-shaped, rounded at the sides, pointed at the rear, where it does not divide the rear coxæ. There are rounded prominences opposite the 1st, 2nd, and 3rd coxæ. It is thickly covered with long coarse hair and upstanding bristles, particularly thick at the side edges, opposite coxæ 1 and 2.

The abdomen is ovate, rounded in front, obtusely pointed at the rear, thick at the sides. There are two shoulder-humps on the upper side. From between these to the base it is thickly covered with short thick upstanding spines, of which there are also some few in other parts. It is moderately thickly covered with downlying rather coarse hair both on the upper and under side. From the rear end of the upper side to the spinnerets the abdomen sinks perpendicularly a distance equal to the length of the cephalothorax.

The epigyne is of the curious upright pillar type, a stout thick

rounded column rising from an oval muscular scape. The anterior portion is club-shaped seen from behind, but a flattened wedge from the side.

The legs are moderately long and stout, the anterior end of the tibial joints being flattened and broadened out. There are bare streaks on the sides of these, but none above. The thick hair is downlying and smoother than in other parts, and there are no spines above either on these or the patellæ, though several at the sides.

The femoral joint of the palpi is curved inwards, broadest and flattened at the anterior end. The tibial joint is twice as long as the patellar, and numerous upstanding spines and bristles cover the whole length.

The measurements (in millimetres) are as follows:—

		Long.	Broad.			
Cephalothorax...		5	{ $2\frac{1}{4}$ in front. 4			
Abdomen.....		11			9	
Mandibles		$2\frac{1}{4}$				
		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.	
Legs	1.	$1\frac{3}{4}$	6	$6\frac{1}{2}$	6 =	$20\frac{1}{4}$
	2.	$1\frac{3}{4}$	$5\frac{1}{2}$	6	$5\frac{1}{2}$ =	$18\frac{3}{4}$
	3.	$1\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$ =	13
	4.	$1\frac{3}{4}$	$5\frac{1}{2}$	5	5 =	$17\frac{1}{4}$
Palpi		1	2	2	2 =	7

A small non-adult male has the scalloped black stripe at the anterior end of the abdomen and the black scallop bordering the inner pattern at the posterior end, on a yellow-grey ground.

Group GASTERACANTHÆ.

Genus GASTERACANTHA Sund.

GASTERACANTHA MINAX Thor.

10 females and 1 male, P. D. M. 6 females, T. H.

This spider is found in considerable numbers from the east coast of New South Wales, through Victoria and South Australia to the Indian Ocean in Western Australia, its place being taken on the north coast by *Gasteracantha vittata* Thor., which appears by far the most common species there. These specimens are from the most northerly point yet recorded for the species.

GASTERACANTHA MINAX Thor., var. LUGUBRIS L. Koch.

5 females; all black, no bright markings.

GASTERACANTHA MINAX Thor., var. ASTRIGERA L. K.

6 females; black, with orange spot on sternum.

GASTERACANTHA MINAX Thor., var. *HERMITIS* nov. (Pl. I. fig. 6.)

4 females. Abdomen pearl-grey above, legs, cephalothorax, and sternum bright orange.

I have previously pointed out (Proc. R. S. Viet. vol. xiii. 1900, p. 79) that specimens of L. Koch's species *Gasteracantha astrigera* and *G. lugubris* were generally found wherever there was a number of *G. minax* Thor., and that there was little or no structural difference between the three. I therefore designated the former as varieties only of the latter.

On this small island we find associated with *G. minax* not only these two varieties, but a third, emphasizing the fact that although very different in coloration they are really only varieties, possibly interbreeding, but all essentially the same species.

The shape of the mandibles, mouth-parts, sternum, vulva, and ocelli markings on the back are the same in every case. The spines, however, often vary in length and shape in the same group of similarly coloured specimens.

Family THOMISIDÆ.

Subfamily MISUMENINÆ.

Group DIETÆ.

Genus DIETA E. Sim.

DIETA ISOLATA, sp. n. (Pl. II. fig. 7.)

The cephalothorax is pale canary-yellow, except over the eye-space, which is quite white, with a few scattered fine white hairs.

The mandibles are darker yellow for the basal half, the anterior half bright pale yellow with pink fangs and yellow-grey fringes. The lip and maxillæ pale yellow. Sternum dark grey at the sides with yellow in the middle and pale yellow-grey hair. The legs and palpi are bright yellow, with yellowish-grey spines and a few whitish hairs. The claw-tufts dark grey on the legs and white on the palpi.

The cephalothorax is straight in front and at the sides as far as the back of the eye-space, whence it is almost round, being very slightly longer than broad ($\frac{1}{4}$ mm.). It is slightly convex at the sides, but quite flat in the middle and a little higher before the rear slope, whence it slopes gradually to the front. On the thoracic part are faint broad shallow striations and a similar longitudinal fovea.

The pedicel joining the cephalothorax and the abdomen is inserted into a hollow in the former.

The clypeus slopes forward and is as broad as the median quadrangle of eyes is long. Both rows of eyes are recurved; those of the front row are almost equidistant, the median 4 times their diameter apart. The laterals, whose diameters are $2\frac{1}{2}$ times

those of the median, are so placed that the line touching their lower edges is the breadth of a median eye from the line across the upper edges of the latter.

The median eyes of the rear row are the same size as the front median, $2\frac{1}{2}$ times their diameter apart, 6 of same from the front median and 8 from the laterals, whose diameter is $1\frac{1}{2}$ times that of the former. This row is more recurved than the front, and about 4 times the diameter of the median eyes wider than the front row.

Each eye is on a separate white tubercle, the side ones being much higher than those of the median. The clypeus is as broad as the area of the median quadrangle is long.

The mandibles are short and broad, kneed at the base, thence divergent, the fangs being particularly short and weak.

The lip is straight at the sides, curving to a blunt point anteriorly, longer than broad, and more than half the length of the maxillæ, which are upright, the inner edges parallel and straight; from a rounded fore corner they slope downwards with a straight edge, thence rounded at the back for about halfway, where they curve in for the reception of the base of the palpi.

The sternum is shield-shaped, as broad as it is long, truncate in front, flat in the middle, but sloping off in front and where it narrows at the posterior end.

The abdomen is rounded in front, gradually widening to about one-third of its length from the base whence, to halfway, the sides are straight; from half its length it narrows to the rear end, where it is just the breadth of the space occupied by its spinnerets. The latter are quite terminal, of equal length, and they have a short second joint. The superior are cylindrical, about two-thirds the thickness of the inferior, which are conical, flattened in front. The epigyne is of a horseshoe pattern, inside of which is a long oval longitudinal depression flanked by two shorter oval hollows in the upper half. The base is a transverse semicylinder.

The femoral joint of the legs is moderately stout, but the latter taper considerably and the tarsal joint is very fine. There are claw-tufts of flat bristles and a few scattered hairs on the tarsus and metatarsus. On the under side of the tibia are four pairs, and one odd one, of long spines, and four pairs of similar long spines on the under side of the metatarsus; otherwise the legs are smooth.

The palpi are short, the femoral joint incurved, the patella as long as the tibia, and the distal joint, thickly covered with short bristles, as long as the two preceding.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	$1\frac{3}{4}$	$\left\{ \begin{array}{l} 1 \text{ in front.} \\ 1\frac{1}{2} \end{array} \right.$
Abdomen.....	$4\frac{1}{2}$	$1\frac{1}{2}$
Mandibles	6	

		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	$\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	2	=	$7\frac{1}{2}$
	2.	$\frac{1}{2}$	3	3	2	=	$8\frac{1}{2}$
	3.	$\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	=	$4\frac{3}{4}$
	4.	$\frac{1}{4}$	2	$1\frac{3}{4}$	$1\frac{1}{2}$	=	$5\frac{1}{2}$
Palpi		$\frac{1}{9}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	=	$1\frac{7}{8}$
Patella = tibia.							

This genus has been described from S. Africa, Asia, and Japan, but no species belonging thereto has previously been noted from Australia. This single female specimen apparently conforms to it in every point.

Family CLUBIONIDÆ.

Subfamily LIOCRANINÆ.

Group MITURGÆ.

Genus MITURGA Thor.

MITURGA PARVA, sp. n. (Pl. II. fig. 8.)

One male (T. H.).

Cephalothorax pale yellow-brown in the middle and at the margin, covered with pale yellowish-white hair; between these areas on each side is a longitudinal darker yellow-brown streak, with brown hair, reaching from the eye-space to the rear. At the margin there are also darker spots, and a thick fillet of yellowish-white hair projecting from the edge outwards.

The mandibles are dark yellow-brown for two-thirds of the length from the base, paler anteriorly, with dingy yellowish-white hair. The fangs are bright yellow-brown.

The lip, maxillæ, and sternum are pale yellow with similar yellowish-white hair rather darker on the fringes.

The abdomen above is yellow-brown, with pale yellow-brown hair. On each side, reaching from the base to halfway, is a brown streak and between these, two narrower, less distinct, streaks, and brown blotches between the end of the side stripes and the spinnerets. At the base are a number of brown bristles. The under side is similarly coloured at the base and sides. Beginning at the genital fovea and reaching nearly to the spinnerets is a wedge-shaped area of black hair broadest anteriorly. On this are two longitudinal rows of large white spots, and on each side a clear white streak bounds the black area. The legs and palpi are dark yellow on the basal part of the femoral joint, getting paler towards the anterior joints, with yellowish-white hair, nearly white scopulæ and claw-tufts, and yellowish-grey spines.

The cephalothorax is ovate, one-fourth longer than broad, convex, thickly covered with coarse downlying hair. Round the outer edge of the thoracic part is a thick fillet of hair extending beyond the margin. There is a long broad longitudinal fovea reaching to the rear slope.

The rear row of eyes is recurved; the median eyes one-third of their diameter apart and their diameter from the side eyes, which are on low tubercles and just slightly smaller.

The front row is straight viewed from in front, slightly recurved from above, all the eyes equal in size to the rear laterals and their diameter distant from the rear median. The median are one-third their diameter apart and half that distance from the laterals. The clypeus is not quite twice their diameter in width.

The mandibles are strong and convex, with long powerful falces and two separated teeth on the inner margin of the falx-sheath.

The lip is broader than long, straight in front, widening to the base, and less than half the length of the maxillæ. The latter are convex, straight on the inner side and at the apex, but rounded at the corners and on the outer side.

The sternum is a broad oval, hollowed opposite the coxæ, and ending in a small point posteriorly well above the contiguous rear coxæ. It is thickly covered with coarse downlying hair in the middle, upstanding round the margin.

The abdomen is oval, twice as long as broad. The spinnerets are terminal, with thick matted hair on the upper side, smoother below. In the superior pair the conical second joint is two-thirds as long as the basal.

The legs are thickly covered with long coarse hair, with numerous short and some long powerful spines on the femora, tibiæ, and metatarsi. There are two spines above on tibia iv. On the under side of tibia i. and ii. are three pairs of spines; also three spines on the inner side of tibia ii., two on tibia i. The claws are short and weak. There are thick scopulæ on all tarsi and metatarsi.

The palpi have the femoral joint incurved, thinner than the other joints, but broadest anteriorly. The patellar joint is shorter and narrower than the tibial, which widens out in front with an apophysis having a curved cusp on the outer corner, but square on the inner.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	5	$\left\{ \begin{array}{l} 2\frac{1}{4} \text{ in front.} \\ 4 \end{array} \right.$
Abdomen.....	6	3
Mandibles	$2\frac{1}{4}$	

		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	1½	5½	6	5½	=	18½
	2.	1½	5½	6	5½	=	18½
	3.	1½	4½	5	5	=	16
	4.	1½	6	7	7	=	21½
Palpi		1	2½	2	1½	=	7

This differs from *M. lineata* Thor., *M. gilva* L. K., *M. agelina* E. S., *M. occidentalis* E. S., *M. severa* E. S., *M. ferina* E. S., besides other points, in having a black area with white longitudinal lines on the under side of the abdomen, and having darker spots but no continuous line along the margin of the cephalic part of the cephalothorax.

From *M. thorelli* E. Sim., in having the front median eyes smaller than the rear median and one cusp only instead of two on the tibial apophysis of the male palp.

From *M. maculata* H. R. H., *M. whistleri* E. Sim., *M. impedita* E. Sim., and *M. catagrapta* E. Sim., besides numerous points which will be gathered from the descriptions, in having three spines on the inner side of tibia ii. and two spines on the inner side of tibia i.

Subfamily SPARASSINÆ.

Group DELENEÆ.

Genus OLIOS Walck.

OLIOS CALLIGASTER Thor.

3 females (T. H.) non-adult.

1 female (P. D. M.) non-adult.

These specimens, despite the fact that none of them is fully developed, are all larger than those measured by Thorell and L. Koch from the eastern and southern parts of the Continent. In other particulars they quite agree with the original descriptions.

The under side of all the patellæ and tibiæ is marked with alternate stripes of brilliant silver-grey and brown instead of partly yellow, possibly because they are younger.

The measurements (in millimetres) are as follows:—

		Long.	Broad.				
Cephalothorax...		9	{	6 in front.			
				7			
Abdomen.....		14		9			
Mandibles		4½					
		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	3½	9½	10	9½	=	32½
	2.	3½	10	10½	10	=	34
	3.	3	7½	8½	7½	=	26½
	4.	3½	8½	9	8½	=	29½
Palpi		1½	4	3	3	=	11½

OLIOS HERMITIS, sp. n. (Pl. II. fig. 9.)

1 female (P. D. M.) non-adult.

2 females (T. H.) (1 ceph. only).

These specimens, none of which is quite adult, are very close to L. Koch's *Olios* (*Sarotes*) *procerus* from the east coast. They differ, however, in the front median eyes being smaller instead of larger than the rear median. The clypeus is as wide as the distance between the front and rear median eyes—plus the diameter of a front median. The lip is less than half the length of the maxillæ instead of half as long, and the legs are more equal in length, the fourth pair being equal to the front pair, and the second only slightly longer. It is therefore worthy of being made a new species.

The cephalothorax is yellow-brown, with a rather broken yellow-brown marginal stripe on the thoracic part, a similar horseshoe pattern of large brown spots nearer the centre with a single spot between the forward pointing open ends. The eyespace is black-brown, and there are two fainter brown spots behind the rear row. The hair is fine and silvery white, but brown on the spots. The mandibles are yellow with a brown stripe on the outer edge reaching rather more than halfway from the base, and the fangs are brown. On the inner edge of the falx-sheath are three large teeth followed by one small one; on the outer margin one large between two small. The lip, maxillæ, and sternum are darker yellow with brown bristly hair.

The legs are orange, with three brown rings on the femur, 1 on the patella, 2 on the tibia, and 2 on the metatarsus of each leg. The scopula on the metatarsus and tarsus are grey, and the claw-tufts nearly black. There are two very long spines, one in front of the other, on the under side of the tibial joint. The tarsal claws are long, with about 10 pectinations on a straight shaft bent at the anterior end, and the female palp-claw has about half that number.

The measurements (in millimetres) of the largest (front pair of legs only) and of a smaller whole one, are as follows:—

	Long.	Broad.				
Cephalothorax...	6	{ 3 in front. 5½				
Abdomen.....	8					
Mandibles	3					
	Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs 1.	2	9½	11½	9½	=	32½
Palpi.....	1	3½	3½	3½	=	11½
	Long.	Broad.				
Cephalothorax...	4½	{ 2 in front. 4				
Abdomen.....	5	3½				
Mandibles	2					

		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	$1\frac{1}{2}$	7	8	7	=	$23\frac{1}{2}$
	2.	$1\frac{1}{2}$	7	$8\frac{1}{2}$	7	=	24
	3.	$1\frac{1}{4}$	6	7	6	=	$20\frac{1}{4}$
	4.	$1\frac{1}{2}$	7	8	7	=	$23\frac{1}{2}$
Palpi.....		$\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{2}$	2	=	$7\frac{3}{4}$

There are two quite young specimens having the front row of eyes straight and of equal diameter—the median pair being their diameter apart, but only half that distance from the laterals. Sternum yellow.

They do not seem to agree with any described species, but are too young to found one on.

Another still smaller seems to be the same, but the front median eyes are apparently farther apart in comparison with their diameter, and one-half that distance from their laterals.

Subfamily MICARIINÆ.

Group MICARIÆ.

Genus MONTEBELLO, gen. nov.

This differs from *Pecilipta* Sim. in having the cephalothorax only slightly less broad posteriorly than in its widest part between the 2nd and 3rd coxæ, whence it narrows to the front, which is truncate. The clypeus distinctly narrower than the front median eyes. The abdomen tapering posteriorly. The area of the median eyes broader than long; the front median larger than the others; the rear row straight or slightly procurved. The 4th pair of legs only moderately longer than the others.

M. TENUIS, sp. n. (Pl. II. fig. 10.)

The cephalothorax is pale yellow-brown with a metallic sheen. The mandibles greyish yellow on the basal half, yellower on the anterior, fangs yellow. Lip, maxillæ, and sternum greyish yellow with grey fringes on the former and pale grey hair on the latter. The legs and palpi are pale yellow with almost white hairs, grey spines, and dark grey claw-tufts. The abdomen is pale yellow on the upper side with short fine dark, and some lighter grey hairs, and a darker median longitudinal stripe on the posterior half; on the under side it is pale yellow all over.

The cephalothorax is truncate in front, longer than broad, rounded at the rear, only slightly narrowing posteriorly from its widest point between the 2nd and 3rd coxæ. From this point it also narrows anteriorly, where it is $\frac{2}{3}$ of its greatest breadth. It is convex, sloping rather steeply to the edge in the cephalic part, and to a flat marginal area at the sides of the cephalic. There is a short thin longitudinal fovea at the top of the rear slope. There are no radial markings, the surface being quite smooth and only a few hairs at the rear of the eye-space.

The rear row of eyes is slightly procurved, equal in diameter, the median being three diameters apart and two of the same from the laterals, and the same distance from the front median. The

median-eye areas broader than long. The front eyes, $1\frac{1}{2}$ times the diameter of the rear, are the diameter of the latter apart; they are the same distance from the front laterals, the row being nearly straight. The front and rear laterals are of equal diameter, $1\frac{1}{2}$ of that distance apart. The rear median eyes are sessile, all the laterals on slight protuberances and the front median still more protuberant. The clypeus is only half as broad as a front median eye.

The mandibles are straight on the outer side, slightly kneed at the base, and as long at the front of the cephalothorax as broad, only diverging from each other anteriorly to the extent of the slope of the falx-sheath. The fangs are moderately curved, slight and fairly long; on the inner margin of the sheath are two equal-sized teeth, and on the outer, one equally long between two smaller. The lip is broader than long, rounded anteriorly, straight at the sides but narrowing slightly to the base, with the anterior margin protuberant. It is not more than one-third the length of the maxillæ. The latter are straight at the anterior margin, nearly parallel at the inner and outer sides, but just rounded at the front corners and widening near the base at the insertion of the palpi.

The sternum is oval, twice as long as broad, narrowing to a point at each end. It is convex with deep depressions in the margin between each pair of coxæ; the rear pair of the latter are contiguous and longer than the rest.

The abdomen is not quite twice as long as broad; it is rounded in front, but not scutate, widest about the genital fold, whence it narrows evenly to the spinnerets, which are quite terminal and of equal length, the inferior pair contiguous, conical, with quite short hemispherical second joint, the superior cylindrical with a similar short rounded second joint. There are no plumose hairs.

The legs are short and slender, the tarsal joints flat, the two claws have 7 or 8 pectinations, a few long spines and bristly upstanding hairs on the tibial and metatarsal joints, and claw-tufts of spatulate bristles.

The palpi are inserted at the lower end of the maxillæ, the femoral joint incurved and broadened at anterior end.

The measurements (in millimetres) are as follows:—

		Long.	Broad.			
Cephalothorax...		$2\frac{1}{2}$	{ 1 in front. 1 $\frac{1}{2}$			
Abdomen.....		$3\frac{1}{2}$	2			
Mandibles		1				
		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.	
Legs	1.	$\frac{1}{2}$	$1\frac{1}{2}$	2	$1\frac{1}{4}$	= $5\frac{1}{4}$
	2.	$\frac{1}{2}$	$1\frac{1}{2}$	2	$1\frac{1}{4}$	= $5\frac{3}{4}$
	3.	$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{2}$	= $4\frac{3}{4}$
	4.	$\frac{3}{4}$	2	2	2	= $6\frac{3}{4}$
Palpi		$\frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	= 2

There is one female specimen only (P. D. M.), and the epigyne is not clear enough to draw.

Family LYCOSIDÆ.

Group LYCOSEÆ.

Genus LYCOSA Latr.

LYCOSA CLARA L. Koch.

A number of females, only one apparently adult, although they are mostly larger than L. Koch's specimens.

The epigyne is more like L. Koch's drawing of that of *L. crispipes*, but it otherwise differs from the latter in too many points to be confused with it, and agrees in all others with *L. clara*. Moreover, the epigyne of the two forms are not very dissimilar with the exception of the ogee-shaped anterior curve of the latter, which is so unusual as to suggest that there may have been some distortion in the specimen from which L. Koch's drawing was made.

The measurements of the largest (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	10	$\left\{ \begin{array}{l} 3 \text{ in front.} \\ 4 \text{ below.} \end{array} \right.$
Abdomen.....	9	7 between 2 and 3 pairs of coxæ.

		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	3	9	$9\frac{1}{2}$	10	=	$31\frac{1}{2}$
	2.	3	9	$8\frac{1}{2}$	$9\frac{1}{2}$	=	30
	3.	3	$8\frac{1}{2}$	$8\frac{1}{2}$	10	=	30
	4.	3	10	10	12	=	35
Palpi		$1\frac{1}{2}$	4	$2-2\frac{1}{2}$	$2\frac{1}{2}$	=	$12\frac{1}{2}$

Family OXYOPIDÆ.

Genus OXYOPES Latr.

OXYOPES ? MUNDULUS L. K.

Four females, of which one only is adult. The eye-plan is the same in all, and they have numerous flat hairs on the under side of the abdomen, but the younger are all darker in colouring and might be different.

They are rather close to several of L. Koch's species, which are not easy to distinguish. In pattern and size they seem nearest to *O. mundulus*, *O. amœnus* L. K., and *O. variabilis* L. K., to all of which the epigyne might conform.

The measurements (in millimetres) are as follows:—

	Long.	Broad.
Cephalothorax...	3	$\left\{ \begin{array}{l} 1\frac{1}{2} \text{ in front.} \\ 2 \end{array} \right.$
Abdomen.....	6	3
Mandibles	$1\frac{1}{4}$	

		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.		
Legs	1.	$\frac{3}{4}$	4	$3\frac{1}{2}$	4	=	$12\frac{1}{4}$
	2.	$\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	=	$11\frac{3}{4}$
	3.	$\frac{3}{4}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	=	$8\frac{1}{4}$
	4.	$\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$5\frac{1}{2}$	=	$13\frac{1}{4}$
Palpi		$\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	1	=	4

Genus PEUCETIA Thor.

PEUCETIA MARGARITATA, sp. n. (Pl. II. fig. 11.)

The cephalothorax is pale yellow mottled with white and brown upstanding bristles. The eye-space is black and dark yellow-brown, with white downlying flat lanceolate hairs. Mandibles, lip, maxillæ, and sternum bright yellow, fangs of former darker orange. The legs are bright yellow on all joints, with long grey spines and upstanding brown bristles on brown roots. There are short, fine, white scattered hairs on the femoral joints, short brown hairs on the others.

The cephalothorax is longer than broad, rounded at the sides and rear, narrowed in front. It slopes gradually from the sides of the thoracic part, but steeply from the cephalic, with a nearly perpendicular clypeus three-quarters the length of the eye-space.

The cephalic part is clearly separated by depressions from the thoracic part, and there is a deep longitudinal fovea on the rear slope. On the median line are three pairs of bristles with circular roots.

The rear row of eyes is procurved, so that the uppermost points of the laterals are on a line with the lowest part of the median. They are equidistant, but the median are quite perceptibly larger than the laterals, and their distance apart is rather more than the diameter of the former.

The eyes of the second row (the laterals of the front row) are the largest and most prominent of any, their diameter being equal to that of the rear median and a front row combined. They are this distance from the rear laterals. The front row (or front median) are two-fifths the diameter of their laterals (2nd row), their diameter apart, and the same distance from their laterals. The clypeus is the length of the quadrilateral formed by the rear median and 2nd row of eyes.

The mandibles are as long as the cephalothorax is broad in front, conical and slightly kneed at the base, with scattered upstanding bristles on the front and hair on the inner and outer sides. The fangs are broad at the base, but short and weak. The margin of the falx-sheath is smooth but with a fringe on the outer margin.

The maxillæ are long and narrow, rounded anteriorly, and parallel at the side, bending forward over the lip, which is twice as long as it is wide halfway up, but broadens out at the base; it is rounded anteriorly and more than half the length of the maxillæ.

The sternum is shield-shaped, straight in front, rounded at the rear, where it is nearly as broad as in front, the rear coxæ being $\frac{3}{4}$ of their width apart.

The legs are long and fine, tapering anteriorly. They are only sparsely furnished with short downlying hairs on the femoral joints, and short bristly upstanding ones on the other joints. There are five or six pectinations on the superior tarsal claws. There are three pairs of long spines on the under side of all tibiæ, two pairs underneath the metatarsi and about five shorter at the anterior end of same.

The abdomen is broken in each specimen, but in one of them the epigyne is intact; it is roughly similar to, but more elaborated than that shown in L. Koch's drawing of the only species previously recorded from Australia.

The measurements (in millimetres) are as follows:—

	Long.	Broad.						
Cephalothorax...	3	{ $1\frac{1}{2}$ in front. $2\frac{1}{2}$						
Mandibles	$1\frac{1}{2}$							
		Coxæ.	Tr. & fem.	Pat. & tib.	Metat. & tars.			
Legs	1.	$\frac{3}{4}$	5	$4\frac{1}{2}$	5	=	$15\frac{1}{4}$	
	2.	$\frac{3}{4}$	4	4	4	=	$12\frac{3}{4}$	
	3.	$\frac{1}{2}$	$3\frac{1}{2}$	3	$3\frac{1}{2}$	=	$10\frac{1}{2}$	
	4.	$\frac{3}{4}$	4	3	4	=	$11\frac{3}{4}$	
Palpi		$\frac{1}{4}$	$1\frac{1}{4}$	1	$\frac{3}{4}$	=	$3\frac{1}{4}$	

Two females sent by Mr. Haynes.

These would seem to differ from *P. albescens* L. K. in the lighter and brighter colouring, in having no row of dark spots on the side slopes of the cephalothorax, in the greater length of the legs compared with the cephalothorax (4 to $3\frac{1}{2}$), and the clypeus not so long as the eye-space, and the more defined epigyne.

Family ATTIDÆ.

Group MARPISSEÆ.

Genus MARPISSA C. Koch.

MARPISSA RIDENS, sp. n. (Pl. II. fig. 12.)

The cephalothorax is black-brown on the cephalic part, dark yellow-brown on the thoracic. On the former and on a marginal stripe are downlying white hairs interspersed with orange. The side slopes and posterior end are bare; on the clypeus is a fringe of coarse orange-coloured hair.

The mandibles are black-brown with a few brown bristles on the basal half. The fangs are dark yellow-brown.

The lip and maxillæ yellow-brown, paler at the margins, with dark grey fringes and brown upstanding hairs.

The sternum dark yellow-brown with white hairs.

The abdomen on the upper side has a broad median area from base to spinnerets of coarse white hair interspersed with orange and upstanding brown bristles; on each side of this is a longitudinal stripe of black hair reaching the whole length. The sides and under side are yellowish white. The spinnerets and epigyne are dingy yellow-brown, with bright yellow inside the chitinous ring of the latter.

The legs are pale yellow with white hair, brown spines, and dark grey claw-tufts. The palpi are thickly covered with long white upstanding hair.

The cephalothorax is nearly $1\frac{1}{2}$ times as long as it is broad, straight in front, rounded at the rear, slightly narrowing from about the middle to the front row of eyes. The cephalic part is flat above, sloping slightly to the sides, as does also the thoracic part, which is rather more convex, but has a broad shallow transverse depression at its anterior end.

The eye-space is broader than long, the rear row being narrower by almost one-fourth than the cephalothorax at that point. The small eyes of the second row are rather nearer to those of the rear row than to the front laterals, and lie in a line between their centres.

The front row is slightly recurved, the median eyes being close together; the laterals, half their diameter, are clearly separated from them and lie rather farther back. The clypeus is half the breadth of the front median eyes.

The mandibles are short, flat and rather divergent, with moderately long tapering fangs. There is one tooth, strong and conical, on the inner margin of the falx-sheath, and two smaller near together on the outer.

The maxillæ are upright, rounded anteriorly and at the outer margin.

The lip, longer than broad, is more than half the length of the maxillæ. It curves inwards from near the front, but is nearly straight at the end. The front pair of coxæ almost meet at their bases, and with their trochanters cover the lower part of the lip and maxillæ.

The sternum narrows to a point between the front pair of coxæ, broadens to its greatest width above coxæ iii., and ends in front of the fourth pair, which are close together.

The front two pairs of coxæ are parallel, pointing forwards at an angle of 45 degrees from the median line, the rear two pairs similarly pointing backwards at right angles to the front pairs, the 2nd and 3rd being slightly separated. The rear coxæ are longer than the others, which are all about the same length.

The front pair of legs are stouter than the others, the femur being flat and club-shaped. The patella and tibia are longer than the metatarsus and tarsus in all legs, the latter joint shorter than the metatarsus.

On the under side of tibia i. and ii. are three pairs of short

spines, under metatarsus i. and ii. two similar pairs. On tibia iii. and iv. is a single pair, and a bunch at the end of the metatarsus of same. The femoral joint of the palpi is incurved and broadest at the anterior end, the tibia longer than the patella.

The abdomen is rather longer than the cephalothorax, truncate in front, straight at the sides for $\frac{2}{3}$ of its length, whence it narrows to an obtuse point; the epigyne is a chitinous oval ring thickest at the posterior end, granular inside, with two small club-shaped protuberances therein near the lower end.

The measurements (in millimetres) are as follows:—

		Long.	Broad.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									</
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This may be distinguished from any of the recorded Australian species by the black lines on the back of the abdomen and the pattern of the epigyne.

Another smaller specimen, apparently of the genus *Marpissa*, has contiguous front coxæ longer than the rest, weaker mandibles, and tarsus i. as long as the metatarsus, but is too broken to describe.

EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. *Tetragnatha angulata*, sp. n. ($\times 2$). a. Mandible from outer side. b. Mandible from inner side. c. Epigyne.
 2. *Nephila meridionalis* Hogg, var. *hermitis*, nov. (nat. size). a. Underside of abdomen. b. Profile. c. Eyes.
 3. *Argiope hynesii*, sp. n. (nat. size). a. Underside of abdomen ($\times 2$). b. Epigyne. c. Eyes.
 4. *Larinia montagui*, sp. n. ($\times 2$). a. Eyes. b. Epigyne.
 5. *Araneus reversus*, sp. n. (nat. size). a. Male (non adult), $\times 2$. b. Eyes of female. c. Epigyne. d. Epigyne from side.
 6. *Gasteracantha minax* Thor., var. *hermitis*, nov. a. Epigyne.

PLATE II.

- Fig. 7. *Dieta isolata*, sp. n. ($\times 2$). a. Eyes and mandibles. b. Epigyne.
 8. *Miturga parva*, sp. n. (nat. size). a. Eyes. b. Underside of abdomen ($\times 2$). c. Male palp.
 9. *Olios hermitis*, sp. n. (nat. size of immature). a. Eyes. b. Lip and maxillæ.
 10. *Montebello tenuis*, gen. et sp. n. ($\times 2$). a. Eyes. b. Mandibles. c. Lip, maxillæ, and sternum.
 11. *Peucetia margaritata*, sp. n. ($\times 2$). a. Eyes. b. Epigyne.
 12. *Marpissa videns*, sp. n. ($\times 2$). a. Eyes. b. Epigyne. c. Lip, maxillæ, left mandible, and first pair of coxæ.

7. On the Nests of Pseudoscorpiones: with historical notes on the Spinning-Organs and observations on the Building and Spinning of the Nests. By H. WALLIS KEW, F.Z.S.

[Received January 5, 1914: Read March 3, 1914.]

INDEX.

Ethology :	Page
Pseudoscorpiones: moulting-, brood-, and winter-nests.	94
Method of building and spinning the nests: <i>Chelifer</i> and <i>Obisium</i>	102
Structure :	
The spinning equipment: historical account.....	99
External spinning-organs of the chelicerae	100

I.

The False-Scorpions' ability to spin was denied by some of the older writers, *e. g.* by Frisch (1), and doubted by others, *e. g.* De Théis (4), but it is now known that they construct nests in part or wholly of silk from their own bodies. Balzan (15) named a species *Chelifer nidificator*; but the nests are not peculiar to particular species or groups. They are known for *Chelifer*, *Cheiridium*, *Garypus*, *Garypinus*, *Olpium*, *Obisium*, and *Chthonius*: genera which represent both main divisions of the Order—Panctenodactyli and Hemictenodactyli—and the four main families—Cheliferidæ, Garypidæ, Obisiidæ, and Chthoniidæ; and it is thus probable that these structures are common to all Pseudoscorpiones*.

The purposes for which the nests are made are known—at least satisfactory statements on this head exist—and the nests themselves, which have often a more or less elaborate covering of extraneous matters, have been described with more or less detail and accuracy by several writers. When one enquires how they are made, however, no answer is forthcoming. The manner in which the extraneous matters are collected and arranged is unknown; and as regards the spun-tissue, the position of the silk-glands and external spinning-organs was long mis-stated; and the subject is still surrounded with uncertainty. With the exception of a statement by Menge (6), which has proved to be mistaken, no description of the animals' methods is known; and it does not appear that the drawing out of the silk has ever been witnessed.

It is proposed here to give a brief re-statement of the subject, and to record some direct observations.

* The construction of nests is the only use the animals are known to make of their spinning. They have been said, by this means, "to envelop the eggs in a cocoon" (17). But no False-Scorpion covers its eggs with silk; and since the eggs are not laid, the egg- and brood-pouch remaining attached to the mother, the thing is impossible.

II.

As already stated, the purposes for which the nests are made are known; but they are inadequately stated in most of the books. The animals thus enclose themselves for moulting, for brood-purposes, and also in some cases for hibernation. Nests for moulting are probably universal and made by all individuals of both sexes. They protect the animal during ecdysis and the periods of helplessness which precede and follow it. Those for brood-purposes, made by females, are probably universal in that sex; but in exceptional cases they are slight and easily overlooked. They protect the distended animal and attached egg- and brood-pouch, and also the young, which remain for a time enclosed with the mother*. Nests for hibernation are probably less general. It is certainly true of some species, perhaps of many, that most individuals of both sexes rest in nests during winter. In these they are protected no doubt from cold; and perhaps also from moisture, which might freeze around them with harmful results.

III.

References to the nests in published papers, and my own notes on the subject, are too numerous to be collected here. It may be permissible, however, to pass in review the main groups and to refer more particularly to a small number of species. Godfrey (29, 36) is the author who more than anyone else has attended to these structures.

Of the families of Panctenodactyli—Cheliferidæ, Feaellidæ, and Garypidæ—the last two are foreign to our fauna and their nests are unknown to me. Those of Feaellidæ do not appear to have been observed. It is otherwise with Garypidæ. Lucas, in 1849 (5), wrote of *Olpium pallipes* Luc., that it lives under or in the crevices of stones where it constructs “une petite coque sans issue, d’un tissu soyeux, serré, revêtue à l’extérieur de grains de sable et de parcelles de terre.” *Garypinus capensis* Ell. is stated by Godfrey (36) to make nests, between flakes of bark of trees, “of silk only without any covering of dust or specks of wood.” According to Becker (10) the nest of the large *Garypus* of the Mediterranean—*Garypus litoralis* L. Koch of this author—is “une coque de soie hermétiquement fermée.” He refers also to similar silken nests of *Garypus minor* L. Koch. These last are more particularly described by Barrois (22), who found them

* Bouvier (21), writing of the nests of the large *Garypus* of the Mediterranean, has indicated that they contained brood-pouches developing in the absence of the mother; and some prominence has been given to this statement by With (27). Further observations, however, convinced Bouvier that he was mistaken; the mother had doubtless escaped, leaving the brood-pouch behind, subsequently to the collection of the nests. It is possible, however, that some species, e.g. *Cheiridium museorum* Leach, may cast off the brood-pouch and leave it in the nest after the larvæ have ceased to suck; cf. Godfrey (29). To recur to the *Garypus*, Becker (10) tells us that he found “les deux sexes réunis dans une coque de soie”; an observation which stands alone and deserves investigation.

on the shore at Villefranche attached to the under-surface of stones: "Chaque loge se compose d'une espèce de petite capsule de forme arrondie tapissée intérieurement par un feutrage blanc auquel adhèrent extérieurement de menues parcelles de terre ou de débris végétaux." He adds that they were completely closed, the animal apparently remaining imprisoned all the winter*. In Cheliferidæ the nests have frequently been mentioned, and I have had opportunities of examining those of several species. The earliest reference for "*Chelifer*" is that of Hermann, 1804 (3), who mentions the occurrence of one of these animals "dans un follicule soyeux, enduit de poussière et attaché à une paroi par un de ses côtés." Of the four sub-genera of *Chelifer*, there is a mention of nests of *Withius* by Godfrey (36), who refers without particulars to those of *C. simoni* Balz. In *Atemnus*, the same author found *C. feae* Ell. "in a very roomy nest on a gum-tree"; and to this sub-genus belongs Balzan's *C. nidificator* (15), found under flakes of a tree-trunk, in "nidi, in forma di cellule contigue, di una sostanza cerosa, biancastra, simile alla seta di certi ragni." In *Chelifer* s. s. and *Chernes*, I will refer to two species of the former *C. cancroides* Lin. and *C. latreillii* Leach, and to two of the latter *C. cyrneus* L. Koch and *C. cimicoides* Fabr.†. *C. cancroides* Lin., which is well-established but doubtfully indigenous with us, lives in stables and such-like places. Godfrey (29) found its nests in a loft in Glasgow in narrow crevices in old harness. He describes them as "closed elliptical rings of dust particles, within which was the inner silken lining appressed throughout the extent of both upper and lower surfaces against the leather." They belonged evidently to immature individuals, and some of them contained cast-skins. A few years ago I examined a colony of this animal in stables at Grays. Between the double boards of the stall-partitions were spaces separated into compartments by the uprights and completely closed in; and on some of these boards being removed many nests were found on their inner surfaces. These spaces of course were much too wide to admit of the nests being attached both above and below; and, as is usual in such cases, the tissue of the floor only was attached to the wood and was continued above as a free convex roof. They bore externally a partial covering of extraneous fragments. Most of them were inhabited; and in at least two were found females with the brood-pouch attached. *C. latreillii* Leach is a maritime species with us, occurring along our eastern shores. On those of Fifeshire and East Lothian it is found in rock-crevices; and Godfrey (29) states that its nests, used for moulting and also, he believed, for hibernation, are large and made generally

* The quotation is from Dr. Barrois' well-known "Mémoire sur le développement des *Chelifer*," the subject of which was in reality *Garypus minor* L. Koch. I am indebted to the author for specimens of the animals and to M. Simon for obligingly examining them.

† For the nomenclature of British and Irish species referred to in this paper, cf. Kew (33).

between two closely placed pieces of rock; they are formed, he says, of earth with a silk lining and with a silken floor and roof attached to the rock. In several English counties the animal inhabits the sand-dunes of the coast; and under these conditions I have often observed it, especially in Lincolnshire, where it is abundant on the fine range of dunes which extends from the Humber to the Wash. In such places it makes its nests for the most part in old sheathing-bases of marram-grass (*Ammophila arenaria*) and sometimes under bark of maimed stumps of *Hippophaë rhamnoides* and *Sambucus nigra*. Those made for brood-purposes are frequently slight in texture, the animal being distinctly visible within. Of nests for hibernation I am not able to say anything not having observed the animal in winter. The moulting-nests, however, are of the usual dense tissue; and when in relatively wide spaces they have usually a free roof. In such cases and whenever there is any considerable expanse of free tissue there is usually a regular covering of grains of sand. *C. cyrneus* L. Koch and *C. cinnicoides* Fabr. are forest species found under rather close-fitting bark of dead or partly dead standing trees. I have already given notes of the nests of the former observed in Sherwood Forest (26), and more recently have had many opportunities of observing them in Richmond Park*. The brood- and winter-nests are surprisingly large, even for this large species, having frequently a diameter of 10 mm. They are built usually in narrow crevices, and thus they do not as a rule exhibit a free roof. This feature is commonly seen, however, in the smaller moulting nests. The free membrane has usually a covering of woody fragments, which is often dense and beautifully regular. The nests of *C. cinnicoides*—smaller in accordance with the smaller size of the animal—have been observed by me in many places, and particularly in Epping Forest, where they are readily found under the bark of the old pollards. The brood-nests are apt to be slight and informal in this species; but the moulting- and winter-nests are ordinarily stout and often exhibit a free roof; and they are remarkable for the density and regularity of the almost invariably complete covering of woody fragments. To the same family belongs *Cheiridium*, whose nests are unusually small and flat. *Cheiridium museorum* Leach occurs, e.g., behind the boards of old barns where the nests are often crowded together in great numbers. They have a diameter of about 2 mm.; and the roof, which is very slightly convex, has a close covering of minute miscellaneous objects. The nests of *Cheiridium ferum* Sim. are still smaller and scarcely, if at all, convex; they are pearly white and quite destitute of attached particles. This at least was the condition of a number sent to me by Godfrey, who found them under flakes of pine-bark in Brittany. Subsequently (36) he

* I am indebted to His Majesty's Office of Works, and to Mr. S. Pullman, the Superintendent of the Park, for the permission and facilities necessary for observing and collecting in this place.

found the same animal in South Africa with many nests under bark of gum-trees. The structures were similar to those above mentioned, of white silk only, and very conspicuous.

In Hemictenodactyli—families Obisiidæ and Chthoniidæ—the nests of both *Obisium* and *Chthonius* are known. The first note for *Obisium* is by Menge, 1855 (6), who found a brood of young “mit der alten Mutter in einem halbrunden Gespinnst zwischen zwei Blättern.” Löw (7) records a female with brood-pouch in a snail-shell; of which the mouth “mit einem dichten, weissen, homogenen Spinnengewebe völlig verschlossen war.” According to Simon (9), *O. jugorum* L. Koch in the frozen regions of the Alps constructs a nest “presque arrondie et sans ouverture, dont le tissu agglutinant se recouvre de terre et de brindilles végétales.” The common *O. muscorum* Leach was observed in detail in Scotland by Godfrey (29). The favourite site for its nest is the under-surface of a stone, but other situations such as the face of a rock covered with herbage or a bed of moss on a tree-stump may be selected. The structure is usually strongly domed. It consists externally of earth, earth and sand, or earth and rotten wood, and internally has a close firm lining of silk, which is continuous, as usual, not only over the interior of the built parts but also over the enclosed surface of the object to which the nest is attached. In the south-west of Ireland there is a larger species, *O. carpenteri* Kew (32), whose nests I found abundantly under loose flakes of ragged outer-bark of *Arbutus unedo*. They are larger than those of *O. muscorum*, and differ in having no regular covering of earthy or woody fragments. The dense white spun-tissue of the nest is in fact usually quite free from extraneous particles. Both moulting- and brood-nests occurred on the trees; and in addition, many of the former were found in rock crevices. *O. maritimum* Leach, another large species, lives below high water-mark on the sea-shore, where it occurs in deep-seated rock-crevices and under large embedded stones. Its nests—first mentioned by Ferrounière (24)—have been observed by Godfrey in Scotland (29), by Jackson in the Isle of Man (28), and by me in Devon and Cornwall and in Ireland (32, 34). They occur in the situations just indicated and, as in the case of *O. carpenteri*, the dense white spun-tissue has no coating of extraneous matters. Spun amidst surroundings constantly moist, they are stout and tough; and, contrary to what is usual in these structures, they are not always intimately attached to the surfaces on which they rest. Thus the nests, together with the enclosed animal, can be removed without injury. When thus removed they have the character of a complete bag of silk, and are sufficiently impervious to retain the enclosed air after long submergence in spirit. Finally, for *Chthonius* we are indebted to Godfrey (29) for notes on *Chth. rayi* L. Koch and *Chth. tetrachelatus* Preys. He describes the nests as built up usually of particles of earth and other chance objects, and lined

with silk, or less commonly formed in holes in stones, etc., the cavity in that case being lined with silk and the entrance closed in with a film of the same material*.

IV.

The nests throughout the Order, and for whichever purpose they are made, are less divergent in character than might be supposed from the foregoing details. Their essential features are everywhere much the same. The completed nest is a closed cell of silk with or without a complete or partial covering of extraneous matters externally. From this the animal has to cut or break its way out when it wishes to emerge. Viewed from above, the structure is roughly circular; but in other respects its form varies with the build of the animal and with the nature of the habitat. In the case of the more flattened animals which inhabit crevices the structure is often compressed. The silk in these circumstances is often spread over and attached to solid surfaces both above and below; and the films thus attached, which form the floor and roof of the nest, are continuous with and connected together by a circular wall. At other times, in spaces relatively wider, the film of the floor only is thus attached, and this film is continued above as a free, more or less convex, roof. In the case of less flattened animals living among stones, in vegetable débris, etc., the floor may be similarly attached and be surmounted by a pronounced dome; or the nests may be made in roundish cavities, or more frequently attached here and there to surrounding objects, and their form is then roughly globular. In all cases, however, there is variation from individual to individual, the animals enclosing themselves in convenient spots of varying character. The creature is always rather closely surrounded, though with ample room for free movement, and thus the differences in the size of the nests follow rather closely those of the makers. In the work of adult individuals there is a range of diameter from about 2 mm. to 10 mm. or more. The external covering of extraneous matters when it exists consists for the most part of earthy or vegetable fragments. It may be complete or partial, dense or sparse, and occur over the unattached parts of nests of whatever form. Some such covering is characteristic of the nests of many species; but in certain others it is invariably absent. The fragments are never over-spun, that is to say, bound on by threads passing over them, but they are always firmly attached to and form part of the structure. They never affect the interior, which is always free from foreign substances and smooth. The spun-material has the character of a thin dense whitish tissue, presumably largely impervious to moisture, and opaque, or

* Godfrey mentions that some of the nests of *Chth. tetrachelatus* had within them a second "silk cocoon of exquisite texture and quite separate from the first lining." This might result, perhaps, from the re-utilization of old nests. But Godfrey saw so many of these "double linings" that one can scarcely dismiss the subject with this suggestion.

nearly so. This tissue, unlike that of many spiders, does not tear with a distinct floss. Its consistency is comparable with that of thin silk-paper; and one would not suppose, even on examination with a strong lens, that it was composed of separately spun threads. With more ample magnification the construction becomes more or less obvious; but it is difficult to say what the arrangement is. Threads in extraordinary number and closeness, and most of them extremely fine, are crossed and re-crossed and turned about in irregular confusion. They appear to have been brushed on by long-continued effort, and no doubt in a viscid condition since they have coalesced to a large extent. The completed tissue is entirely without interspaces. When incomplete, threads of varying strength, in a more or less open, irregular meshwork, are observable*.

V.

From what part of the animal⁶ does the material for this tissue proceed? It was supposed that the glands were in the abdomen and that their ducts opened near the genital aperture in numerous separate spinnerets. This view was started by Menge, 1855 (6); and it remained unquestioned for more than thirty years. Even after Croneberg had shown it to be wrong, restatements of it continued to appear, not only in text-books, but in memoirs dealing specially with this Order: cf. Cambridge, 1892 (17). It was in 1887-8 that Croneberg (12, 14) showed that the glands indicated were really accessories of the genital system, and that the supposed spinnerets were merely part of the bristle-armature of the external genital-area. At the same time Croneberg found that in *Chelifer* (*Chernes*) there were glands in the cephalothorax with ducts opening in the chelicerae; and Bertkau (13), working during the same years and independently, made similar discoveries in *Obisium*. Both authors concluded that these were the real producers of the silk; and all that was required was confirmation from observations on living animals. Such observations, however, were not made; and in the meantime various considerations have confused the subject; so that, as stated recently by Godfrey (29), the spinning in this Order is still surrounded with uncertainty. Menge was well known to have supported his anatomical investigations with detailed descriptions and figures; and apart from these he had had living animals under observation. He had even described the movements of an individual which made part of a nest under his eyes. Croneberg and Bertkau, on the other hand, had arrived at their conclusions on morphological grounds alone. On such grounds, moreover, Supino (23) had dismissed these conclusions, regarding the organs in question as a poison-apparatus, and falling back as regards spinning-organs on a view

* The only previous note on this tissue known to me is by With (25). He examined nests of *Chelifer sculpturatus* Lewis, and was surprised to find that the threads were not independent but fused, so that a complicated system of thinner and thicker threads was formed. He adds that the structure was difficult to explain; and that the newly formed threads had perhaps fused before drying.

almost identical with that of Menge. Further, Bernard (18) had suggested that certain structures, which he believed himself to have discovered on the ventral face of abdominal somites V. to XI., were possibly the openings of spinning-glands. We have seen, however, that Menge was certainly wrong. With (27) has already stated that Supino was mistaken; and the same remark applies to Bernard, whose misconception was ridiculed at the time by Hansen (20) and soon abandoned by the author himself. But there were other difficulties. Ducts had certainly been seen in the chelicerae, but it was not clear that their openings had been fully made out; and Hansen had examined the supposed place of disembogement in *Obisium muscorum* Leach with results which he was unable to regard as satisfactory. He may perhaps have had before him an adult male in which the spinning-function had degenerated*. However this may be, he seems to have regarded Croneberg and Bertkau's conclusions as justifiable; "but it ought to be examined if the animals actually do spin with these organs." So also With (27) has concluded that spinning is at least one of the functions of the chelicerae; but proof of it was still wished for.

VI.

The required confirmation of the correctness of Croneberg and Bertkau's conclusions is afforded by observations now recorded. The spinning is done by the chelicerae. These appendages are of two segments: a hand prolonged into a fixed finger, and a movable finger articulated to the hand; and they are provided with special structures, of which one is entirely and another partially or entirely comb-like. The whole appendage is relatively small in *Panctenodactyli*, and relatively large in *Hemictenodactyli*; and several differences in the special structures are characteristic of these main divisions. In all *Panctenodactyli* the movable finger is provided, on its outer margin just before the apex, with a small, almost transparent, more or less flexible, projecting structure known as the galea. In *Hemictenodactyli* this structure is present or absent; and in its absence the hard chitin of the finger, in exactly the same position, is raised to form a small, more or less convex, laterally compressed tubercle. Croneberg's researches in *Chelifer* (*Chernes*)—representing the first of these main divisions—showed that the ducts from the cephalothoracic glands passed into the hand of the chelicera, four or five into each, and thence into the movable finger, which they traversed to near the apex, where they entered the galea. Within the galea they distributed themselves into the small branches of that structure, and at the terminations of these branches they opened. Bertkau found in *Obisium*—representing the second main division—that the ducts similarly traversed the chelicerae

* Bertkau states of *Obisium* that the glands, which were well developed in all the females he examined, were absent in some of the males, though the ducts remained in the chelicerae.

to a point identical with that reached by those of *Chelifer* (*Chernes*). There was here no galea; but the ducts entered the hard tubercle replacing that structure, and on or near the margin of this tubercle they opened. The number of ducts in each chelicera was about ten—or, according to one of the later papers of Bernard (19), about seven; and one may note that on the tubercle of *O. muscorum* Leach, examined by Hansen, six minute openings appeared to exist. It is thus established that the galea and the tubercle which may replace it are correctly regarded as the external spinning-organs in this Order*. These structures bear no resemblance to one another; and no intermediate condition is known. The galea is obviously a sheath within which the ducts are carried forward beyond the apex of the finger. Its presence or absence does not appear to be associated with differences in the spinning or resulting tissue. Assuming Pantenodactyli to be the older group, it seems that the increasing size of the chelicerae in Hemictenodactyli may have rendered this projecting organ dispensable. The structures are always well developed, whichever one is present, in the young of both sexes and in adult females; and this no doubt is in relation to the spinning of moulting- and brood-nests. In adult males they may be fully developed or degenerate. In the former case it will be found, I believe, that regular winter-nests are spun; while in the latter case presumably the male spins but little or not at all after arriving at maturity. The character of both structures differs throughout the Order from species to species. Among the forms assumed by the galea the most complicated is that in which it is branched from a short stout base, the branches being re-branched, so that the shape of the organ recalls that of the antler of a stag. More usually it has a long, rather stout shaft, with about six small, simple branches distally. But it may be trifid or merely styloform. The tubercle may be rather high with a convex outline, or lower or longer and more flattened.

The other structures of the chelicerae, the combs, etc., have nothing to do with the spinning†.

* Thorell, 1883 (11), gave prominence to spinning (and chelate appendages) in the name "Chelonethi," with which he proposed to replace "Pseudoscorpiones." The spinning-openings were then supposed to be in the abdomen; but afterwards (1890), with references to Croneberg and Bertkau, he remarked on the increased propriety of the name, observing that the creatures not only possess chelæ and spin but spin with the chelæ (of the chelicerae). At the same time he proposed the name "procursus textorius" for the galea (16); and we find that Ewing (35) has already written "spinneret" for both galea and tubercle.

† It has been stated repeatedly that these combs—the serrula and lamina interior—manipulate the silk; but in reality they are not concerned in any way with the spinning-work, never coming into contact with the threads or with the spun-tissue. The mistake is attributable to Bernard (19), who converted into a direct statement an ingenious but incorrect suggestion of Croneberg's. To these structures another supposed silk-combing organ, said to be like the antenna of a Lamellicorn beetle, has been added by Shipley (30) and Warburton (31). This last is one of the inventions of Stecker (8; cf. Hansen 20); nothing like it exists in nature. The so-called "flagellum," which occurs in the position indicated, is merely a row or tuft of peculiar bristles; it is of unknown use and certainly not connected with spinning.

VII.

There remains the enquiry how are the nests built and spun; that is to say, how do the animals collect and fix the extraneous matters of the exterior, and how do they fabricate the spun-tissue?

Godfrey's field-work showed that the external coating was the first part of the work, the silk lining being produced afterwards and necessarily from within. This was evident from inspections of nests in various conditions of incompleteness; but the animals were not seen at work. To make the required investigations in the open was scarcely possible. It was necessary obviously to have captive individuals under observation; and this in conditions favouring the undisturbed performance of their functions, and at the same time permitting prolonged watching. Several naturalists, from Röscl 1755 (2) onwards, have kept the animals in captivity; and it has usually been found that nests were constructed; but Menge alone makes mention of the animals' procedure. He placed a *Chelifer* (*Chernes*) in a glass vessel and discovered next morning that a nest had been commenced. He found the animal still busy, by continued movements of the body somewhat like those of the spider *Clubiona*, increasing the thickness of the web; and he claimed from this to have seen the spinning. That the animal was so engaged there is no doubt; but since Menge was mistaken as to the position of the spinning-organs it is evident that no precise observation had been made. The writer's attempts to watch the animals in captivity commenced in 1904; and since that time one or more species have usually been under observation. They were housed in small flat cases of cork and glass, forming cells with an area of three square inches and a height of from a quarter to an eighth of an inch; and in these they lived in health for long periods. Their surroundings were made as natural as possible, and the nests they constructed were in most cases quite like those made in their natural habitats. The creatures were examined under moderate magnifications, the cells being placed bodily on the stage of the microscope. Such examinations were necessary from time to time; but much could be made out with no other aid than that afforded by a good hand-lens. The species whose nest-making was observed in detail were two of *Panctenodactyli*, *Chelifer cyrneus* L. Koch and *Chelifer latreillii* Leach; and one of *Hemictenodactyli*, *Obisium muscorum* Leach.

Chelifer cyrneus L. Koch—belonging to the subgenus *Chernes*, and eyeless—was the subject of most of the observations. It is a large heavily-built species; and the galea is long-shafted, equally developed in both sexes, and provided distally with six small branches*. The specimens were obtained from narrow

* These branches are less easy to count than might be supposed. For the present species, Tömösváry gives four and Schtschelkanowzeff five; yet there are undoubtedly six.

spaces under the bark of partly dead oaks; and the cells in which they were placed were provided with strips of decayed wood from these trees. The arrangement was such that narrow spaces were left between the strips of wood and the glass of the cells. Colonies thus established—strengthened by fresh importations from time to time—were under observation for two years; and at the time of writing, two cells contained together eleven nests: some on the floors of the cells, with a complete convex roof, and others of more compressed form in the spaces between the wood and the glass.

At various seasons certain of the animals, either young or adult, became distended—no doubt from accumulated nutritive matters—and it was in this condition that they enclosed themselves either for moulting, for brood-purposes, or for the winter. Such an individual restlessly perambulated the cell, investigating the corners and crevices, every now and then picking up with the palp-fingers and removing dead insects and other scattered objects; and occasionally, at such times, it detached fragments from the wood, taking hold of them with the palp-fingers and using considerable force. It was evidently prospecting for a position for the nest. At length, having decided on one, it was soon at work on it with the chelicerae, and usually by the following morning or evening it had arranged round itself a complete ring of fragments of wood, etc. It was now unsafe to abandon the post of observation, for the animal got to work with rapidity and within about twelve hours had generally completed the external coating or framework of the nest, the builder being then—except in those cases in which the glass formed the roof—entirely concealed from view.

The manner in which the animal constructed this framework and enclosed itself within was the subject of numerous observations. But the procedure may be indicated by taking the case of the making of a brood-nest with a complete convex roof, the observation of which extended almost from beginning to end. The distended builder was restlessly moving about in the morning, and in the evening of the same day was found to have taken up a position on the floor of the cell, where it had already surrounded itself with a ring of fragments. These were of wood and cork and mostly small—sawdust from the borings of *Dryocetes villosus* for the most part—and they were all definitely placed in position and secured from within to the floor and to each other by threads of silk. They formed already the beginnings of the narrow circular wall of the nest. This was at 6 P.M., at which time the animal was within the circular space and full of business. For the continuation of its work it would require evidently a quantity of material, much of which would have to be procured from a distance. Coming up close to the wall, the animal extended the palps over it and felt about for fragments on the floor beyond. Finding some, it withdrew and proceeded with its work; or, failing to find any, it stepped over

the wall and explored the floor farther afield. Finding the necessary supply without going far, it returned to the nest by stepping backwards, going in over the wall abdomen first; or, more often, having to go to a distance, it returned with a forward locomotion, re-entering the nest head first. The fragments were found and picked up with the palp-fingers, whence they were immediately transferred to the chelicerae, the animal never carrying material home in the palps. Except in the case of large fragments it was not satisfied with one, but picked up a number in succession, transferring each as found to the chelicerae, its actions while thus engaged recalling those of a bird accumulating nest-materials in its bill. The smaller fragments were received between the fingers of the chelicerae, the fixed fingers going over and the movable galea-bearing fingers under them; and as the materials accumulated they appeared to be attached together by silk from the galeae. Larger fragments, while always kept in contact with the chelicerae, and apparently more or less attached with silk, were sometimes supported in part by the hand or other segments of the palps, or even on the dorsal shield of the head; and in this way was brought in at least one fragment nearly as big as the animal itself. At the conclusion of each collecting expedition the animal returned impatiently to the nest; but once within, it turned about and deliberated before placing the materials. At length, running the burdened chelicerae into some part of the top of the wall, it managed thus to release the fragments; and it now got to work at once, attaching them together and to those already placed by dabbing silk on their inner surfaces and stretching threads from one to the other. During this proceeding the palps were brought round so that the great hands and fingers of these appendages were close to the inner surface of the wall, the animal evidently directing the work by the sense of touch which the hairs and perhaps other sense-organs give to these parts. Occasionally it adjusted the fragments by propping them with the hands and fingers of the palps; and sometimes, but rarely, it held them between these fingers while the first few threads were being applied by the chelicerae. Apart from this, it constantly felt with the palps both the inside and outside of the wall, as if to ascertain how the work was progressing. One was particularly interested to see how it extended the palps over the outside for this purpose, its actions bringing to mind those of a bricklayer giving little taps to newly-placed work. There was an air of satisfaction about its behaviour, and with reason, for it was wonderful to see how the wall grew and began to assume the proper curve for the roof. From time to time, as soon as each collection of materials had been placed in position, off the animal went for another supply; and this continued fetching of fragments and building them in was maintained for hours. As the work proceeded, moreover, the task became more and more laborious, for the animal, no longer able to step over the wall, had to climb

up the inside and down the outside each time it went out, and up the outside and down the inside each time it returned; and further, there was increasing difficulty in fixing the fragments against gravitation as the structure converged towards the top of the roof. The animal was watched for five and a half hours, during which it worked untiringly and with care, with brisk and eager movements and without once resting. Its activity was remarkable. When I left it at 11.30 p.m. only a small aperture at the top of the roof remained to be filled in, and thus the framework of the nest was almost complete. It must be explained that the silk dried rapidly, the structure being firm from the first, so that it was little if at all damaged by the continued scrambling in and out of the animal. At the same time a certain elasticity was evident, and thus during the final stages of this part of the work—not seen in the present case—the animal would not be greatly obstructed in forcing its way in and out of the small decreasing aperture. Next day, at 7.30 a.m., the framework was complete, the aperture having been filled in, and the builder was thus entirely enclosed. The creature was still busy, however, within the nest. One could see that the palp-fingers were being applied from place to place, and the structure was temporarily raised or pushed out first in one part and then in another. The animal was evidently spinning, and at the same time re-adjusting the materials to some extent; and it even detached and threw out certain fragments, dried remains of prey etc., which had originally been built in.

The structure thus made consisted of a vast number of irregular, mostly small, fragments of wood and cork fastened together by silk attached to their inner surfaces and extending from one to the other; and the arrangement was such that the interior had a regular approximately even surface. The silken attachments—seen by looking down between the fragments—had the character of an open irregularly joined-up meshwork, of which the threads were of varying thickness, most of them relatively stout. This meshwork ought perhaps to be regarded as the essential frame of the structure; the use of fragments is probably necessary in nests entirely unattached above but otherwise it is not indispensable; for the animal is able, at least in certain positions, to make nests of spinning-work alone. The task of bringing the nest to the condition now indicated had entailed much work; but what remained to be done was more laborious and occupied a longer time. This additional work consisted of long-continued spinning, the meshwork, the inner surfaces of the fragments, and in fact the whole interior, including the floor, having to be covered with silk, until at last every part was lined with the almost paper-like tissue already described.

The making of nests such as that above considered, though showing well the manipulation of the extraneous materials, offered but moderate facilities for observing the spinning. This was better seen in nests made in the spaces between the strips

of wood and the glass. In such a nest the wood formed the foundation for the floor and the glass that for the roof, the built part consisting of a circular wall extending from one to the other. Here one could see something, not only of the making of the framework of the wall, but also of the subsequent spinning, which latter was obscured in nests of the former character. The general proceedings of the animal were easily observed; but it was less easy to make sure of the precise character of the spinning, the task of following moving organs under the magnification required being, even in the most favourable conditions, somewhat difficult. However, it was seen that the silk proceeded from the distal part of the galeæ—there was no doubt that it issued from the tips of the little branches there situated—whence it was drawn as separate, highly viscid, very fine threads. These threads, several from each galea, either remained separate or coalesced into stouter ones, all those from each galea sometimes going to form a single thread. The spinning involved small continuous forward and backward movements of the body, such movements being derived from the joints of the legs without necessary replacement of the feet. The small forward movements brought the galeæ into contact with the objects to which silk was being applied, or with the tissue which was being augmented, and from attachments thus made threads were drawn out during the small backward movements, at which time also there were lateral movements of the chelicerae, the galea-bearing fingers being swung widely open. These small movements of the body, moreover, brought the chelicerae, not always to the same spot, but sometimes a little above or a little below, or a little to the right or to the left; and the chelicerae themselves, it may be explained, are much more mobile than might be supposed, being capable of considerable extension both forwards and laterally. While making the framework the animal was seen to bring the chelicerae into contact with the glass and by small rapid movements to brush on minute confused attachments of separate threads. During this part of the work the creature moved about freely, and the threads thus attached, usually coalescing into one from each galea, were carried from place to place, from roof to floor, or from either of these to the inner surfaces of collected fragments, or from one fragment to another. The threads coalesced at various distances from the galeæ and not all of them at the same point, and since they fused at once either before or after coalescing with other threads or with whatever object they came in contact, the irregular meshwork soon resulted. As the animal continued to work the meshes became closer and closer, till little by little they were filled in. At the same time the animal laboured to cover the floor and roof with silk. At frequent intervals, often throwing back the palps along by its sides, it settled down to long-continued spinning; and at such times it maintained for hours the continuous movements of the body and of the chelicerae already mentioned. By this means silk was rapidly

brushed on to the interior, first in one place and then in another. It fused at once to the substratum, the exceedingly fine threads now usually fusing separately without coalescing one with the other. This was well seen on the roof, where the threads fused to the glass in more or less parallel order in series of several running side by side. An appearance similar to that here presented would be obtained perhaps if it were possible to take the lines from a sheet of music, obliterate one here and there, and turn the rest backwards and forwards in irregular fashion one over the other. The number of threads in a series varied, and in the present species not more than five were counted—that being the usual number; so that it appeared that one or more of the branches of the galea had usually been inactive. With the two galeæ the animal could thus produce at least ten threads at a time; and it will be understood that the original parallel order was soon lost in the general confusion of a closed layer. Continuing thus to work at intervals for many days or even weeks, the animal at length produced the final dense tissue over every part of the interior of the nest. In the case of a perhaps unusually dense moulting-nest, this part of the work occupied the indefatigable energy of the animal during six weeks, the completed structure thus costing incredible labour.

Chelifer latreillii Leach—belonging to the subgenus *Chelifer* s. s., and provided with eyes—was the subject of similar though less numerous observations. The galea is here shorter-shafted; and its distal half is provided with small branches, which in the female—the organ is degenerate in the adult male—are six in number. Specimens were obtained from tussocks of *Ammophila arenaria* on sand-dunes; and the cells in which they were kept were provided with leaves of that grass and with sand. Brood-nests only were made—there were no immature individuals to make moulting-nests—and little need be said of them since the animal's methods were identical in all essential matters with those of *C. cyrneus*. The extraneous materials employed were grains of sand, which the animal carried in the chelicere. Only a little sand was used, however, the spun-tissue being slight in texture and for the most part uncovered externally. The silk was seen to proceed from the galeæ, as before, and that deposited on the glass ran similarly in irregular more or less parallel series; in these, in the present case, six threads sometimes occurred, presumably one from each of the six branches of the galea.

Obisium muscorum Leach, the remaining animal observed, is of vastly different type. It is longer-legged and less solid; and in place of the two dull eyes of *Chelifer* s. s. there are four shining with a white lustre. The chelicere are large and without galeæ. The hard laterally compressed tubercle which replaces the galea has, especially in the female, a bold convex margin, on or near which, as already stated, Hansen more or less satisfactorily detected six minute openings. The animal is common and

easily obtained; but since it requires constantly moist conditions there are difficulties in keeping it for long periods. However, a few were maintained in health for several months; and two females made brood-nests both attached in part to the glass. It had been supposed that the differences in the chelicerae, more particularly the absence of galea, would correspond with differences of method; but the animal's proceedings appeared to be identical with those of *Chelifera*. As with those animals, the framework of the nest was rapidly constructed, the extraneous matters being carried in the chelicerae; and no differences were observed in the manner of spinning or in the tissue. The silk was seen to proceed from the tubercle in several very fine threads, which, more especially during the earlier part of the work, were apt to coalesce, those from each tubercle often forming a single thread. At other times, that is during the formation of the dense tissue, the threads more often remained separate, fusing thus to the substratum, and those deposited on the glass ran in irregularly parallel series, usually six together, presumably one from each of the pores of the tubercle.

It will have been noticed that the number of spinning-openings appears to have been six on each chelicera, twelve in all, in all three species, the presence or absence of the galea counting for nothing in this respect; but this number is not necessarily universal. The branching of the galea, for instance, is a variable feature from group to group. For the rest, however, it may be predicted that the general lines now indicated are those on which all the animals of this Order, whether possessing the galea or not, set about the construction of their nests.

VIII.

Summary.—Pseudoscorpiones make nests in part or wholly of silk from their own bodies. They enclose themselves in them for moulting, for brood-purposes, and in some cases for hibernation. Such nests are closed cells of spun-tissue with or without an external covering of extraneous matters. They are roughly circular, but their form differs with the build and habitat of the animal. They may be attached above and below to the solid surfaces of narrow crevices and thus flattened, or they may be attached below only, in which case they have a free convex roof, or, again, they may be fixed here and there to surrounding objects and roughly globular. The external covering, when it exists, consists of earthy or vegetable fragments, which are not bound on to the structure but firmly attached to it. The interior is always free from foreign matters and smooth. The spun-tissue is thin and dense, almost like silk-paper. It is composed of innumerable threads crossed and re-crossed and coalesced in irregular confusion and without interspaces. The material is derived from glands in the cephalothorax, whose ducts traverse the chelicerae to near the apex of the movable finger, and open at

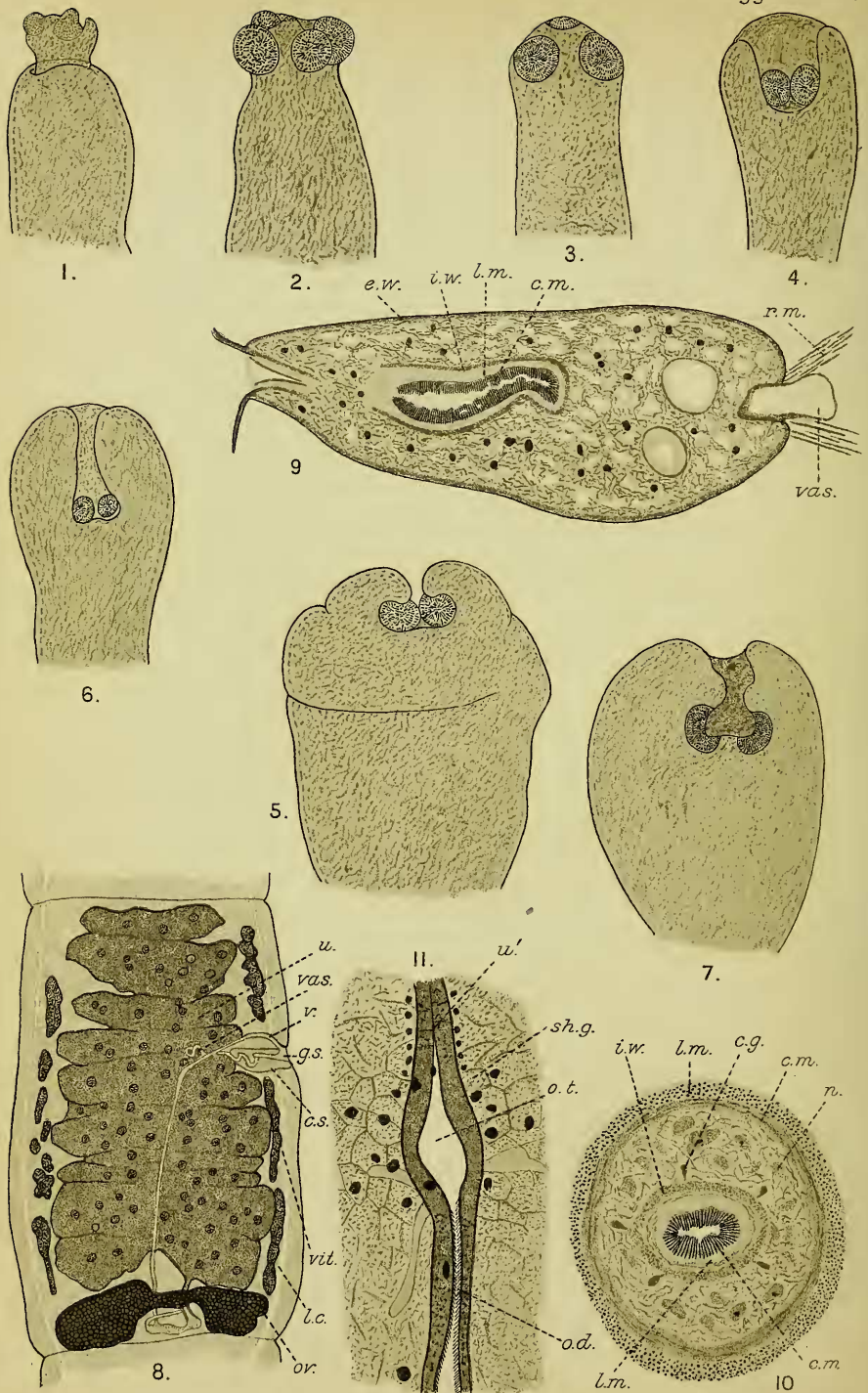
the tips of the branches of the galea or on or near the margin of a tubercle which replaces that structure in some groups. The spinning is thus done with the chelicerae, the galea or tubercle being the structure immediately concerned; and the presence or absence of the galea does not appear to be associated with differences of method or in the tissue. The combs etc. of the chelicerae have nothing to do with the silk. All the nest-making is done from within, the animal gradually imprisoning itself. The construction of an external framework is the first part of the task; and when this has a coating of extraneous matters the animal frequently goes out to collect materials. These it picks up in the palp-fingers, transfers them to the chelicerae, and returns thus laden to the nest, where it attaches the materials together and to those already placed by applying silk to their inner surfaces and stretching threads from one to another. The silken attachments form an open irregular meshwork, which is the essential frame of the nest, and is constructed in some cases without the use of extraneous matters. The silk is drawn from the galea or tubercle in several separate viscid very fine threads, which remain separate or coalesce, all those from each galea or tubercle sometimes forming a single thread. The spinning is associated with continuous forward and backward movements of the body and with lateral movements of the chelicerae. During the earlier parts of the work, when attachments are being made from place to place, the threads usually coalesce, and since they fuse at once, either before or after coalescing with other threads or with whatever object they come in contact, the irregular meshwork soon results. Afterwards the animal settles down to long-continued spinning, and silk is rapidly brushed on to the interior, first in one place and then in another. The threads now usually fuse separately, being applied in more or less parallel series of several side by side; and when both galeae or tubercles are used together ten or twelve threads may be deposited at a time. The animal continues thus to work at intervals for days or even weeks, till the final dense tissue is at last produced over every part of the interior of the nest. The methods of three species, representing both main divisions of the Order, were observed in detail; they were essentially identical and probably characteristic of all Pseudoscorpiones.

IX. *List of References.*

1. FRISCH, J. L.—Beschreibung von allerley Insecten in Teutsch-Land, viii. Berlin, 1730.
2. RÜSEL, A. J.—Der monatlich-herausgegebenen Insecten-Belustigung dritter Theil. Nürnberg, 1755.
3. HERMANN, J. F.—Mémoire Aptérologique. Strasbourg, 1804.
4. DE THÉIS, C.—Lettre adressée à M. Audouin sur quelques Arachnides des genres *Hydrachna* et *Chelifer*. Annales des Sciences naturelles, xxvii. pp. 57-78. Paris, 1832.

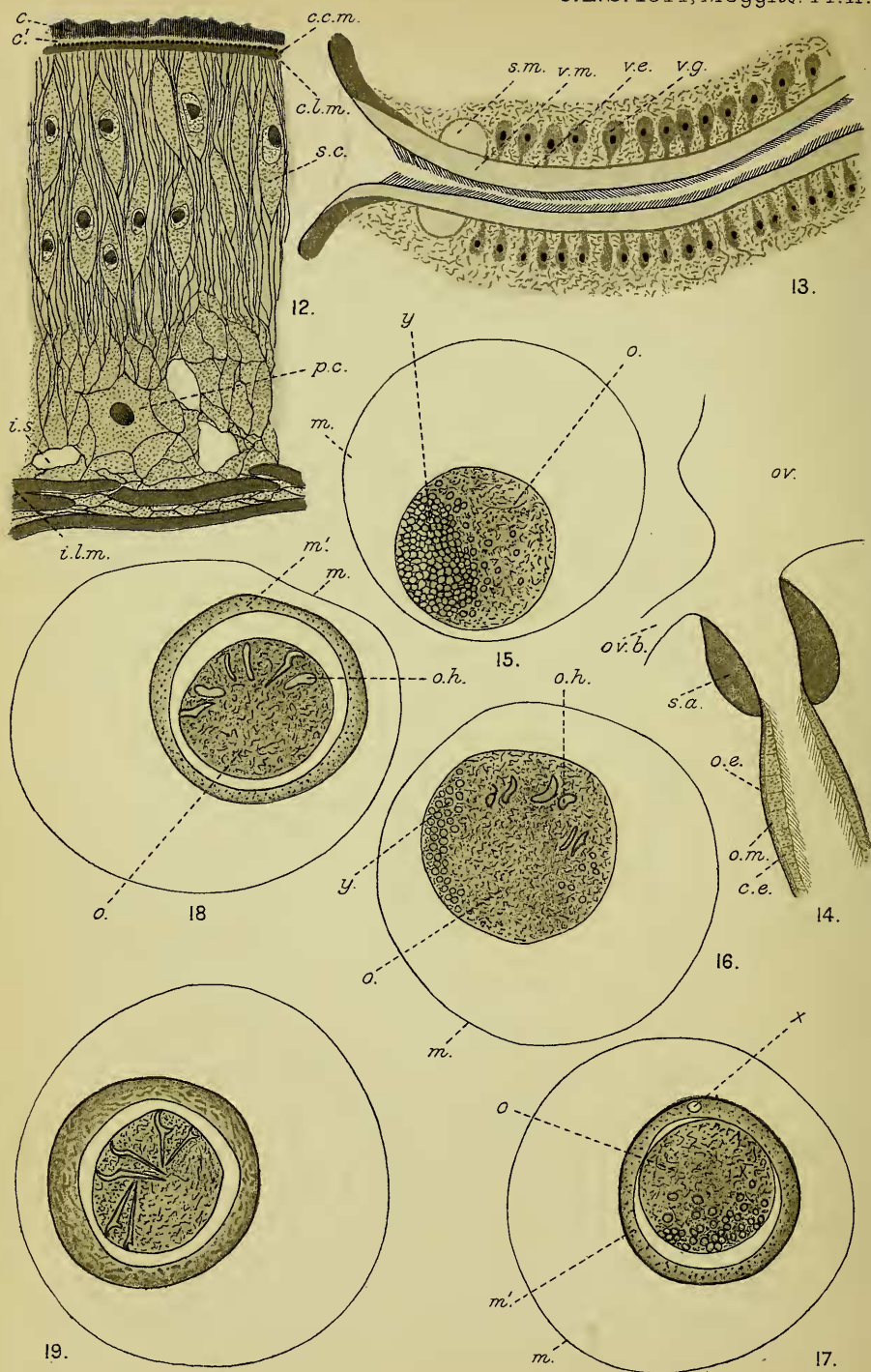
5. LUCAS, H.—Exploration scientifique de l'Algérie. Histoire Naturelle des Animaux Articulés, i. Paris, 1849.
6. MENGE, A.—Ueber die Scheerenspinnen, Chernetidae. Neueste Schriften d. Naturforschenden Gesellschaft, v. pp. 1-43. Danzig, 1855.
7. LÖW, F.—Beobachtungen über das Eierlegen und Spinnen der After- oder Bücherskorpione. Verhandlungen d. K.-K. zoologisch-botanischen Gesellschaft, xxi. pp. 841-3. Wien, 1871.
8. STECKER, A.—Ueber neue indische Chernetiden. Sitzungsberichte d. K. Akademie d. Wissenschaften, Math.-nat. Cl., lxxii. pp. 512-26. Wien, 1875.
9. SIMON, E.—Les Arachnides de France, vii. Paris, 1879.
10. BECKER, L.—Communications arachnologiques. Ann. Société entomologique de Belgique, xxiii. pp. cxxxix-cxlii. Bruxelles, 1880.
11. THORELL, T.—Descrizione di alcuni Aracnidi inferiori dell' Arcipelago Malese. Ann. Museo civico di Storia Naturale, xviii. pp. 21-69. Genova, 1883.
12. CRONEBERG, A.—Vorläufige Mittheilung über den Bau der Pseudoscorpione. Zoologischer Anzeiger, x. pp. 147-151. Leipzig, 1887.
13. BERTKAU, P.—Ueber den Bau der Chernetiden. Verhandlungen des naturhistorischen Vereines der preussischen Rheinlande u. s. w., xlv. Sitz. pp. 112-117. Bonn, 1887.
14. CRONEBERG, A.—Beitrag zur Kenntniss des Baues der Pseudoscorpione. Bull. Soc. Imp. des Naturalistes (n. s.) ii. pp. 416-461. Moscou, 1888.
15. BALZAN, L.—Revisione dei Pseudoscorpioni del bacino dei fiumi Paraná e Paraguay. Ann. Museo civico di Storia Naturale, (2) ix. pp. 401-454. Genova, 1890.
16. THORELL, T.—Aracnidi di Pinang raccolti nel 1889 dai Sigri. L. Loria e L. Fea. *Ibid.* x. pp. 269-383. Genova, 1890.
17. CAMBRIDGE, O. P.—On the British Species of False-Scorpions. Proc. Dorset Nat. Hist. etc. Field Club, xiii. pp. 199-231. Dorchester, 1892.
18. BERNARD, H. M.—Additional Notes on the Origin of the Tracheæ from Setiparous Glands. Ann. Mag. Nat. Hist. (6) xi. pp. 24-28. London, 1893.
19. BERNARD, H. M.—Notes on the Chernetidae. Journ. Linn. Soc., Zool. xxiv. pp. 410-430. London, 1894.
20. HANSEN, H. J.—Organs and Characters in different Orders of Arachnids. Entomologiske Meddelelser, iv. pp. 137-251. Copenhagen, 1894.
21. BOUVIER, E. L.—Sur la ponte et le développement d'un Pseudoscorpionide, le *Garypus saxicola* Waterhouse. Bull. Soc. entomologique de France, lxxv. pp. 304-307, 342-343. Paris, 1896.
22. BARROIS, J.—Mémoire sur le développement des *Chelifer*. Revue Suisse de Zoologie, iii. pp. 461-498. Genève, 1896.

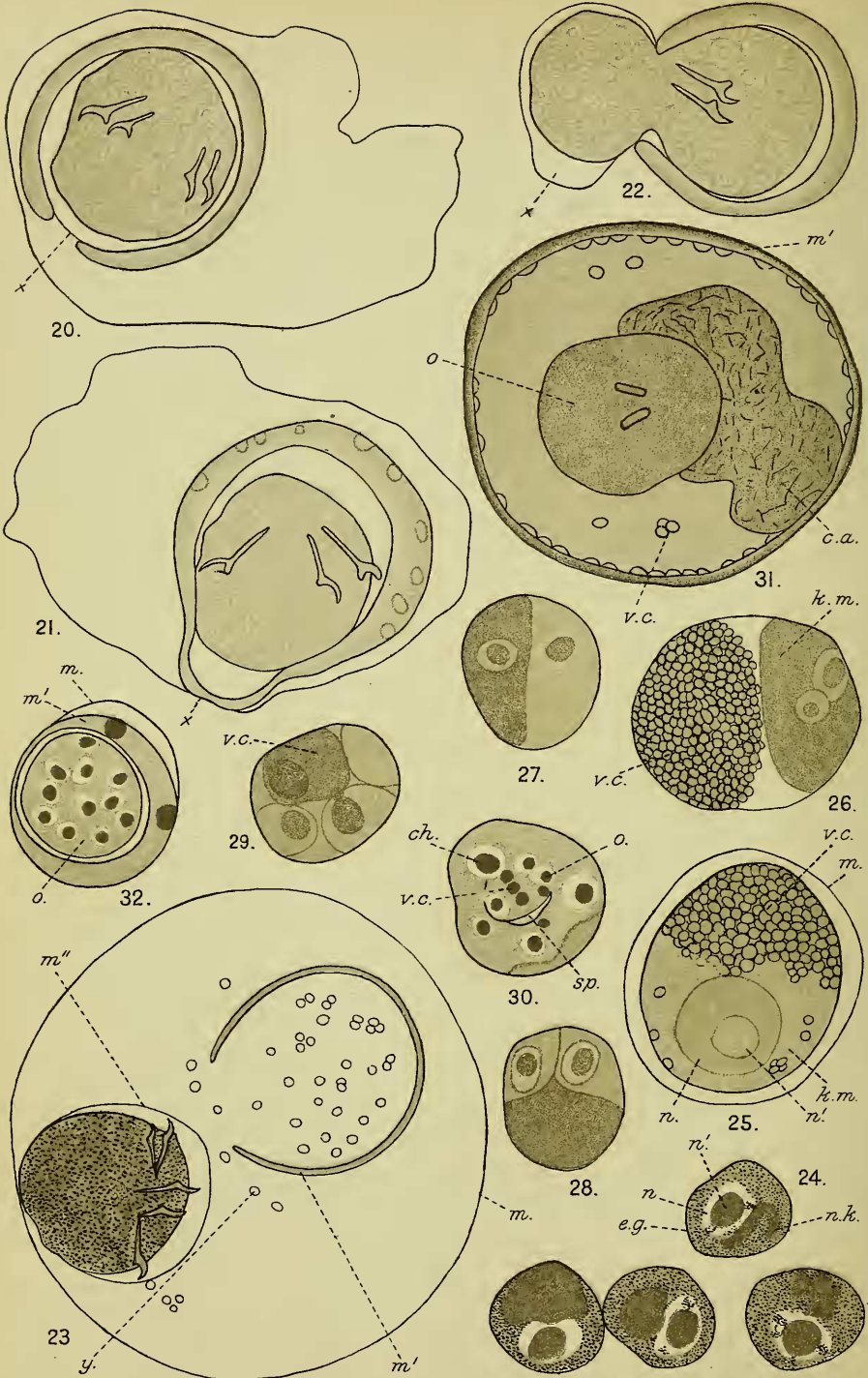
23. SUPINO, F.—Osservazione sopra l'anatomia degli Pseudoscorpioni. Atti della Reale Accademia dei Lincei, (5) viii. pp. 604-8. Rome, 1899.
24. FERRONNIÈRE, G.—Contribution à l'Étude de la Faune de la Loire-Inférieure. Bull. Soc. des Sciences naturelles de l'Ouest de la France, ix. pp. 137-146. Nantes, 1899.
25. WITH, C. J.—On Chelonethi, chiefly from the Australian Region, in the Collection of the British Museum. Ann. Mag. Nat. Hist. (7) xv. pp. 94-143. London, 1905.
26. KEW, H. W.—*Chernes cyrneus* in Nottinghamshire: a recent addition to the known False-Scorpions of Britain. Trans. Nottingham Naturalists' Society, 1905-6, pp. 41-46. Nottingham, 1906.
27. WITH, C. J.—The Danish Expedition to Siam, 1899-1900. Chelonethi: an Account of the Indian False Scorpions, together with Studies on the Anatomy and Classification of the Order. Kgl. Danske Videnskabernes Selskabs Skrifter, (7) iii. pp. 1-214. Copenhagen, 1906.
28. JACKSON, A. R.—Rare Arachnids captured during 1906. Proc. Chester Society of Nat. Science, etc., vi. pp. 1-7. Chester, 1907.
29. GODFREY, R.—The False-Scorpions of Scotland. Annals of Scottish Natural History, xvii. pp. 90-100, 155-161; xviii. pp. 22-26: xix. pp. 23-33. Edinburgh, 1908-10.
30. SHIPLEY, A. E.—In SEDGWICK, A.: A Student's Text-Book of Zoology, iii. London, 1909.
31. WARBURTON, C.—In HARMER & SHIPLEY: The Cambridge Natural History, iv. London, 1909.
32. KEW, H. W.—A Holiday in South-Western Ireland: Notes on some False-Scorpions and other animals observed in the Counties of Kerry and Cork. Irish Naturalist, xix. pp. 64-73. Dublin, 1910.
33. KEW, H. W.—A Synopsis of the False-Scorpions of Britain and Ireland. Proc. Roy. Irish Academy, xxix. B, pp. 38-64. Dublin, 1911.
34. KEW, H. W.—Pseudoscorpiones. In Clare Island Survey. *Ibid.* xxxi. (38) pp. 1-2. Dublin, 1911.
35. EWING, H. E.—Notes on Pseudoscorpions. Journ. New York Entomological Society, xix. pp. 65-81. New York, 1911.
36. GODFREY, R.—In ELLINGSEN, E.: The Pseudoscorpions of South Africa, based on the Collections of the South African Museum, Cape Town. Ann. South African Museum, x. pp. 75-128. London, 1912.



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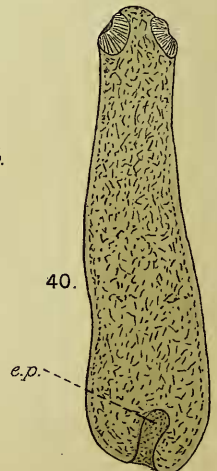
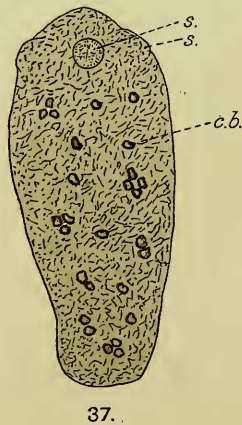
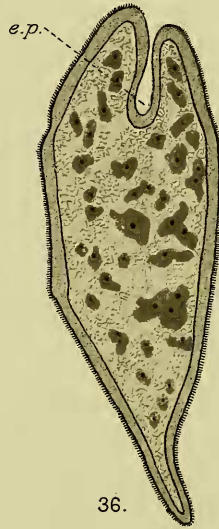
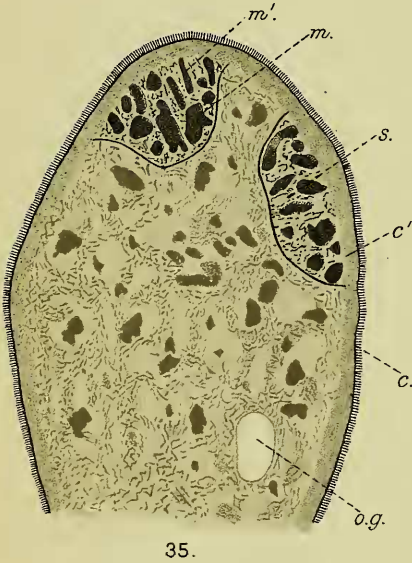
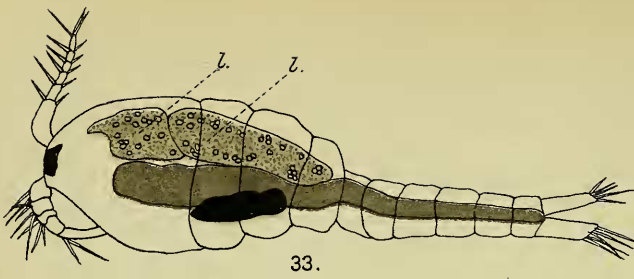
STRUCTURE OF ICHTHYOTÆNIA FILICOLLIS.





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STRUCTURE OF ICHTHYOTÆNIA FILICOLLIS.



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8. The Structure and Life-History of a Tapeworm (*Ichthyotænia filicollis* Rud.) Parasitic in the Stickleback. By F. J. MEGGITT, M.Sc. (Birm.), Board of Agriculture and Fisheries Research Scholar, University of Birmingham *.

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(Plates I.-IV.† & Text-figures 1-5.)

INDEX.	
INTRODUCTION	Page 113
ANATOMY.	
Historical	114
Occurrence	115
External Characters	115
Histology	118
Musculature.....	119
Excretory System	119
Nervous System	121
Male Organs	121
Female Organs	122
LIFE-HISTORY.	
Historical	124
Infection Experiments	125
Development	130
SUMMARY	135
LITERATURE	135

INTRODUCTION.

Ichthyotænia filicollis Rud. (= *Tænia filicollis* Rud.) is a species the life-history of which, like that of most *Ichthyotæniæ*, is practically unknown. No successful infection experiments have been carried out upon any member of the genus, and it was therefore thought that a connected account of the whole life-history would be of service in establishing a complete diagnosis of the family. In carrying out this work it was found that the only two complete descriptions of this species, those of Kraemer (10) and Benedict (3), are said by La Rue (12) to be descriptions of other species: if this be correct, then there is at present no paper giving a detailed and accurate study of this species. The paper is therefore divided into two parts, the first being a detailed account of the anatomy of the specimens obtained, compared with the descriptions of Kraemer and Benedict, and the second an account of the life-history as far as it could be determined.

I wish here to express my indebtedness to Professor F. W.

* Communicated by Prof. F. W. GAMBLE, F.R.S., F.Z.S.

† For explanation of the Plates see p. 137.

Gamble, F.R.S., for the very valuable help he has given me in the course of this work by his criticism and advice. My thanks are also due to Professor G. S. Brady for identifying specimens of *Cyclops varius* Lilljeborg submitted to him.

ANATOMY.

Historical.

This species was first described by Rudolphi (21). He found two species of Cestodes, one in the intestine of *Perca fluviatilis*, and one in that of *Gasterosteus aculeatus*, and called them *Tænia ocellata* and *T. filicollis* respectively. In his original descriptions there is very little to distinguish between the two species.

Early investigators, Bellingham (1), Dujardin (8), Diesing (7), and Cobbold (6), confined themselves to external characters, Zschokke (26) being the first to describe the internal anatomy. Later, Kraemer (10) made an exhaustive study of the two species, and concluded that there was no essential difference between them: in the same paper he gave a number of characteristics peculiar to fish *Tæniæ*, and suggested that they might form a special group. Still later, Lönnberg (15) separated them under the generic name of *Ichthyotænia*. Riegenbach (20), for the first time, summarised the investigations on the genus and added several new species to the list. In 1899, Railliet (19) showed that *Tænia ambigua* Duj. is synonymous with *T. ocellata* Rud. and *T. filicollis* Rud., and that therefore the genus *Proteocephalus* Wein. (25) is synonymous with *Ichthyotænia*: the first being the older name, should be adopted according to him. Benedict (3), who confirmed Kraemer's description and elucidated a few fresh points, adopted this name.

The latest paper upon the subject is that by La Rue (12). He asserts that *Tænia filicollis* Rud. and *T. ocellata* Rud. are two separate species. The species which Kraemer described under those names, La Rue asserts was not *T. filicollis* nor *T. ocellata* but an entirely new species (*P. fallax* La Rue). He further says that Benedict did not describe either of Rudolphi's species, the species actually described being *P. exiguus* La Rue. Zschokke (26) also, according to him, described *P. dubius* La Rue, not *T. filicollis* Rud.

Tetracotylus (Monticelli, 18) he does not consider to be synonymous with *Ichthyotænia*. He adopts the generic name *Proteocephalus* on account of its priority: "I cannot regard the objections of Lühe (16) as adequate for its rejection." This paper is merely a preliminary note to a monograph he is about to publish.

From the brief historical account just given, it is obvious that the nomenclature of the group is in a state of great confusion. This is chiefly due to the vague descriptions of the early investigators, most of them being based upon characters, such as the scolex, which are far too variable to be utilised for

classification. Riegenbach (20) lists 29 species, of which only 7 are satisfactorily described. At the present time, it is impossible to say with certainty whether La Rue is right in retaining the species *Tenia filicollis* Rud. and *T. ocellata* Rud. The only correct part of Rudolphi's description is that referring to the scolex, and since the scolex is very variable, Rudolphi's species cannot be determined with any degree of certainty. The question can only remain in abeyance until the publication of La Rue's monograph.

It cannot be said, however, that La Rue is justified in retaining the generic name *Proteocephalus*. As Lühe (16) has shown, this name was used by Blainville (4) for a family of Cestodes containing *Caryophyllæus*, and for that reason should be abandoned in favour of the next oldest name, *Ichthyotenia*. In the same paper in which La Rue rejects the name *Ichthyotenia*, he proposes the name *Monticellia* for the genus *Tetracotylus* Monti., Braun (5) and Lühe (16) having shown that the latter name was proposed by Filippi to designate a group of immature Trematodes. He thus admits the principle upon which Lühe's objections are based.

Occurrence.

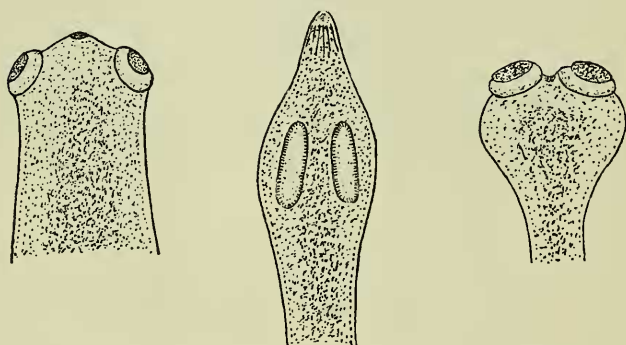
The specimens studied were collected from the intestines of a number of sticklebacks (*Gasterosteus aculeatus* Artdi) taken from the Edgbaston Reservoir. The numbers in a single host varied from one to twenty-five. Almost every fish in autumn was infected with one or more of these parasites, 75 per cent. of which were adult: in winter, the number of infected fish was considerably smaller, and adults were rare; while in spring, the proportion of adults again increased. Adult specimens were found, however, all through the months September to June, but while their proportion to young forms was 75 per cent. in the first month, it was only 15 per cent. in March. Von Linstow failed to find it adult at all in winter, and Zschokke only noticed it three times.

External Characters.

The length of adult specimens varies from 24 to 33 mm., the breadth from 1.0 to 1.2 mm. The head is almost continuous with the neck and is only slightly globular except when violently contracted (text-fig. 1): in Kraemer's specimens it was spherical and sharply marked off from the neck. It is furnished with four suckers, two dorsal and two ventral, and at its apex is a fifth, which is not very well developed although apparently functional. The shape and size of the head and suckers are subject to considerable variation. The whole region of the head anterior to the suckers can be retracted (Pl. I. fig. 5): or the retracted area may even be so large as to include the suckers themselves (Pl. I. figs. 4, 6, 7)—in the latter case, they are hidden in a deep vertical fissure, and can only be seen by staining, while the

scolex appears to have a terminal depression similar to that of *Schistocephalus dimorphus* Crepl. On the other hand, the suckers may stand out as small cups at the four corners of the base of a tetragonal pyramid, the apex being formed by the fifth sucker (Pl. I. fig. 2): the scolex may also be inserted in the neck like a cork in a bottle (Pl. I. fig. 1). It is obvious, therefore, that the shape of the scolex is a character to which little importance can be attached. In life the head undergoes a regular series of changes, passing from an extremely elongated phase to a violently contracted and spherical one (text-fig. 1).

Text-figure 1.

Movements of scolex of *Ichthyotenia filicollis*. $\times 142$.

The diameter of the head varies from $\cdot 166$ to $\cdot 2$ mm., and of the suckers from $\cdot 04$ to $\cdot 07$ mm. The neck is relatively long, and occupies about a quarter of the whole length. The first proglottis separated from it is much broader than long, its dimensions being $\cdot 192$ – $\cdot 397$ mm. broad $\times$ $\cdot 1$ – $\cdot 166$ mm. long. The total number of segments varies from 24 to 33. Kraemer states that the first proglottis is much longer than broad; while Benedict figures two varieties, in one of which it is longer than broad, and in the other is broader than long. Lühe (17) gives it as longer than broad. The following table gives the external measurements according to various observers (Table A). Posteriorly, the segments become longer in proportion to their width, until the penultimate proglottis is $1\frac{1}{4}$ –2 times as long as wide. The posterior proglottis is rounded at the tip, and at its apex is the excretory pore. In my specimens this was often very prominent, opening on a small triangular papilla.

The separation of the proglottides from one another is very indistinct, being indicated in the posterior portion of the strobilus only by a slight notch.

The genital openings are lateral, and alternate irregularly. According to Benedict, there is a small genital sinus, while

TABLE A.

	Length of body.	Breadth of body.	Diameter of head.	Diameter of suckers.	Breadth of neck.	First proglottis.	Number of proglottides.	Length of neck.
Kraemer	60	2	·114	·038	0·76	·228 wide X ·342 long.	50-120	$\frac{1}{4}$ — $\frac{1}{2}$
Benedict:								
1st variety ...	12-16							$\frac{2}{3}$
2nd " ...	15-25	·8	·12	·04	·10-12	·12-20 wide X 1·16 long.	40	$\frac{2}{3}$ — $\frac{1}{2}$ $\frac{1}{2}$
3rd " ...	38							
Lühe	30-100	2	·114				50-120	$\frac{1}{4}$
Meggitt	24-33	1·0-1·2	·166-2	·04-07		·192-397 wide X 1-166 long.	24-33	$\frac{1}{4}$

TABLE B.

	Diameter of calcareous bodies.	Thickness of 1st layer of cuticle.	2nd layer of cuticle.	Circular muscle-layer.	Longitudinal muscle-layer.	Sub-cuticular layer.	Cells of sub-cuticular layer.	Diameter of their nuclei.	Diameter of their nuclei.
Kraemer	·003-·005	·003	·005			·06	·057 X ·02	·008	
Benedict	·005	·0015	·002	·031		·025			
Meggitt		·0033	·002	·0012	·002	·066	·02-·028 X ·007	·005	·003

All measurements in millimetres.

Kraemer states that vagina and cirrus open directly to the exterior. My own specimens confirm the former statement.

Histology.

The body is covered by a two-layered cuticle (Pl. II. fig. 12). The outermost layer is dark-staining and rough in outline, and is split up by vertical clefts into a great number of fine hair-like processes. The whole appearance is that of a cast cuticle. A similar cuticle is present in *Schistocephalus dimorphus* Crepl., and this Kiessling (9) considers to be a disintegration product of the underlying layer: it is probable that this is true of *Ichthyotenia filicollis* also. Under this cuticle is a feebler-staining homogeneous layer. According to Kraemer, there is a third layer ("Cutis") underneath this: in one or two cases in my specimens it has appeared as though there were a third layer, but this is probably only an optical effect. Benedict does not mention it at all.

Following the cuticle is a layer of circular muscle-fibres, and then one of longitudinal muscle-fibres. Internally is a sub-cuticular cell-layer, composed of spindle-shaped cells, $\cdot 02\text{--}\cdot 028 \times \cdot 007$ mm., drawn out into delicate protoplasmic processes internally, and possessing a prominent nucleus, $\cdot 005$ mm. dia., and nucleolus, $\cdot 003$ mm. dia.

The structures above-mentioned appear to vary greatly in size according to different investigators (Table B); it is apparent, therefore, that their size is a character too unstable for classification.

Under the sub-cuticula is the parenchyma. This consists of polygonal cells, with a varying diameter of $\cdot 0046\text{--}\cdot 008$ mm., with nuclei $\cdot 0023$ mm. dia. The cell corners interlace with one another to form a loose meshwork enclosing intercellular spaces, the meshwork being closer externally and less compact between the various organs. The intercellular spaces are often empty, but more usually are filled with a feebler staining granular mass which Kraemer thinks is an excretory product of the parenchymatous cells.

Forming a regular layer under the cuticle in the more posterior part of the body are large numbers of rather small calcareous bodies. They are oval and stratified, rather like starch-grains. In the larval cestode they are much longer and not so stratified, and are scattered irregularly over the body; they show very distinctly under the cuticle, and appear as if actually on the body surface.

There do not appear to be any oil globules comparable with those mentioned by La Rue (11) in *P. filaroides*. If the Cestode be examined in water, numerous transparent bubbles may be seen attached to the body and gradually growing larger; these may correspond to the oil globules and be due to the water round the specimens causing the minute invisible oil droplets on the body to coalesce into larger drops.

Musculature.

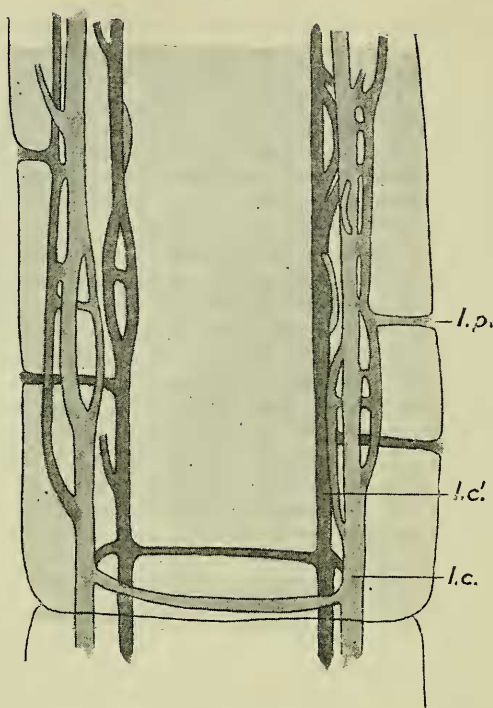
The musculature of the body consists of circular and longitudinal muscles (already described) under the cuticle, and more powerful inner longitudinal muscles (Pl. II. fig. 12). These latter are arranged in bundles, which run in the outer layer of the parenchyma and have a diameter varying from .008 to .0103 mm. (Benedict, .0015 to .004 mm.); anteriorly they diminish in size, although in the scolex anteriorly to the suckers they occasionally have a diameter of .0092 mm. The single fibres of which they are composed are .0035 mm. dia. (Kraemer, .007); occasionally spindle-shaped nuclei, .0028 $\times$.0092 mm., with a prominent nucleolus, .0023 mm. dia., are to be seen, the long axis of the spindle being parallel to that of the fibre. In the body, and especially in the neck, large fibres pass dorso-ventrally between the longitudinal muscle bundles. According to Benedict, "a loose sheet of circular muscle-fibres weaves around the longitudinal bundles. Large fibres pass in a transverse direction between these muscle sheets. The divisions between the proglottides are formed by the interlacing of these fibres with similar ones which cross them at right angles, both sets being here much more complicated than in other regions." He does not figure them, however, and they do not appear to be present in my specimens.

The musculature of the scolex consists of prolongations of the inner longitudinal muscles together with scattered dorso-ventral and sagittal fibres. The suckers have equatorial, meridional, and inner radial muscle-layers; they are covered by a continuation of the body cuticle, which is not absent, as Kraemer states, from their cavities.

Excretory System.

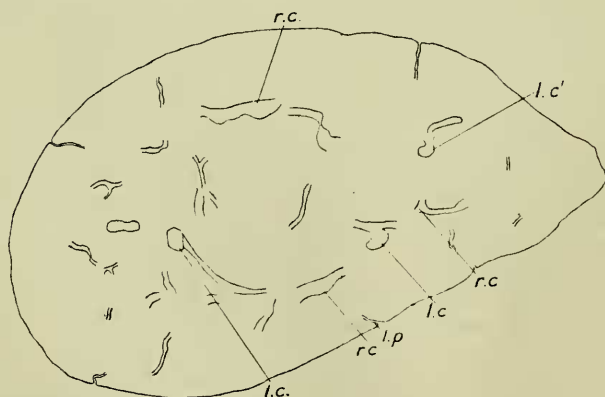
The excretory system consists of four main longitudinal vessels, two dorsal and two ventral, which run, internally to the longitudinal muscles but externally to the yolk-glands, from the scolex to open at the posterior end of the body. They are not, as Kraemer states, of equal diameter, but are unequal, the two dorsal being .0045 $\times$.0068 mm., and the two ventral .002 $\times$.015 mm. In the scolex they end in a circular commissure, .0023 mm. dia., just under the suckers (text-fig. 3). Outside their course in the neck is a system of fine canals forming a complicated plexus from which other fine canals lead, either to the exterior or to the four longitudinal canals. These "foramina secundaria" have, according to Kraemer, a swollen portion at their opening, while the opening itself is guarded by a wisp of hairs. I have never had the good fortune to see the dilatation, the canals apparently having a uniform diameter, .0017 mm., throughout their entire course; the wisp of hairs also I have never seen, although the outer cortex at places presents rather a hair-like appearance. La Rue (11) states: "There exists a wide variation in the types of structures which

Text-figure 2.



Main excretory vessels of a proglottis: reconstructed from camera-drawings of sections. *l.c.*, *l.c'*, ventral and dorsal longitudinal excretory vessels; *l.p.*, lateral excretory pore.

Text-fig. 3.



Transverse section through the neck, showing the excretory plexus. *l.c.*, *l.c'*, ventral and dorsal longitudinal excretory vessels; *l.p.*, lateral excretory pore; *r.c.*, circular commissure. $\times 435$.

are grouped under this name. The 'foramina secundaria' described by Kraemer for *P. ocellata* and *P. torulosa*, and by Riggenbach for *P. fossata*, *P. abscissa* and *Corallobothrium lobosum*, are muscular pulsatile vesicles which open at the posterior lateral margin of each proglottid. Benedict finds no such vesicles for *P. ambloplitis* or for *P. ocellata*, nor do any of the secondary excretory openings seen by me come under the type described by Kraemer and Riggenbach." Throughout their entire course, the longitudinal canals give off many side branches which anastomose with one another and with the main canal; in many cases they end blindly in parenchymatous spaces. At irregular intervals, other lateral branches are given off; these gradually diminish in width and finally open to the exterior. In the neck this anastomosis is much more evident, at times the main canals being lost in the plexus formed.

At the posterior limit of each proglottis, the four longitudinal canals are joined by a circular commissure whose lumen is equal to that of the canals.

The four canals open posteriorly in a notch at the apex of the last proglottis. There does not appear to be any such "Endblase" as Kraemer figures, the canals meeting at one point, from which a common canal leads to the exterior. Instead of the notch there is often a triangular projection at the apex of which is the excretory pore. In young forms there is a very pronounced "Endblase" (Pl. IV. fig. 40) into which the excretory canals probably open, but this disappears in older specimens.

Nervous System.

Owing to the difficulty of staining it, I have not been able to make out the nervous system at all satisfactorily. Anteriorly there is a nervous mass, the "brain," lying between the four suckers and just under the fifth; from it are given off two longitudinal nerve-trunks which run down the lateral margins of the strobilus externally to the excretory system. Benedict describes in addition, four transverse trunks arising from the anterior nerve-mass, each running straight out between the two suckers; about halfway to the margin of the scolex each branches into two secondary trunks, which run at right angles to their previous course as far as the corresponding sucker.

Male Organs.

The testes are spherical bodies, .055 mm. dia., about 40 in number, scattered throughout the entire space between the ovaries and the anterior edge of the proglottis; there is no central layer from which they are absent. Each is tightly invested with an exceedingly delicate tunica propria, not, as Benedict figures, in a loose membrane. In transverse sections they appear hollow, with a cavity divided by septa into a number of small compartments filled with granular matter. Minute vasa efferentia lead from them to a common vas deferens,

·0184 mm. dia. In the centre of the proglottis, this is coiled into a spherical ball, in the coils of which lie the spermatozoa. The walls appear structureless, but have occasional nuclei, $\cdot 0046 \times \cdot 0011$ mm., scattered along them. Benedict states that the coils are bound together by parenchymal strands, but these I have not been able to see. From this coiled portion, a short duct leads to the cirrus-sac, but before entering it, decreases in diameter to $\cdot 008$ – $\cdot 009$ mm.

The cirrus-sac itself (Pl. I. fig. 9) is oval, slightly constricted in the middle, and stretches about $\frac{1}{3}$ – $\frac{1}{4}$ across the proglottis, extending some distance beyond the vitellaria. Its small size in my specimens is surprising, since both Kraemer and Benedict figure it as reaching to the middle line of the proglottis, and its comparative size is one of the characters used for specific distinctions. Its walls (Pl. I. figs. 9 & 10) consist of outer longitudinal muscles, $\cdot 0023$ mm. thick, and inner circular muscles, $\cdot 0023$ mm. thick, with an exceedingly delicate cuticle surrounding them. The basal end of the cirrus-sac is turned rather obliquely towards the dorsal side of the proglottis. Its walls bend back to form a small tube which becomes united with the wall of the vas deferens. This latter, just within the cirrus-sac, has a slight muscular coat which gradually becomes thicker and passes into the muscular coat of the cirrus. The vas deferens is coiled once before opening into the cirrus.

The latter is an almost straight cylindrical tube, without the enlarged distal portion figured by Benedict. It consists of an outer layer of longitudinal muscles $\cdot 003$ mm. thick, an inner one of circular muscles $\cdot 0023$ – $\cdot 004$ mm. thick, and a cuticle bearing fine bristle-like projections externally. The lumen here is $\cdot 0046$ mm. dia. The external cuticle of the body tucks in at the opening of the cirrus-sac and lines the inner wall of the cirrus for some distance. Scattered along the course of the cirrus-tube and opening into it are numerous pear-shaped glands, $\cdot 0034 \times \cdot 0009$ mm.

The space between the inner tube and the wall of the cirrus-sac is filled with fibrous tissue containing many nuclei, $\cdot 0023$ mm. dia., but I have been unable to see the definite fibres figured by Benedict. At the posterior end of the sac are muscles extending from the cirrus-tube into the parenchyma, and probably serving for retraction.

Female Organs.

The aperture of the vagina is $\cdot 008$ mm. in diameter and is just anterior to that of the cirrus-sac. A circular sphincter muscle (Pl. II. fig. 13) encloses the vagina a little within the aperture; it is hemispherical in section, with a diameter of $\cdot 008$ mm. The vagina itself runs back to the middle line of the proglottis, turns at right angles to its former course, and finally opens into the oviduct at the posterior end of the proglottis (text-fig. 4). Its

walls consist of an inner ciliated epithelium—which appears to pass into the cuticle of the body—a muscular layer, and an outer epithelium; altogether the wall is $\cdot 0034$ mm. thick, and the lumen of the tube $\cdot 003$ mm. dia. Along its course, but particularly near its opening to the exterior, are numerous glands, $\cdot 004$ mm. dia. at their widest part $\times \cdot 007$ mm. long, with distinct nuclei, $\cdot 0011$ mm. dia., and having fine ducts opening into the lumen of the vagina. Just before it opens into the oviduct, the walls have a slightly different character. They diminish in width to $\cdot 0029$ mm., the muscular layer nearly disappears, and the main thickness of the tube is due to a layer of cubical epithelium, similar to that lining the cavity of the oviduct. The opening of the vagina into the oviduct is very small.

The ovary is two-lobed. The lobes are elliptical, and are joined anteriorly by a small common portion. Each ovary is surrounded by a delicate membrane, which, according to Kraemer, passes into the sheath of the oviduct. The ovary is usually so full of eggs that their shape is changed by compression from spherical to polygonal. They will be described later in connection with the life-history.

Text-figure 4.

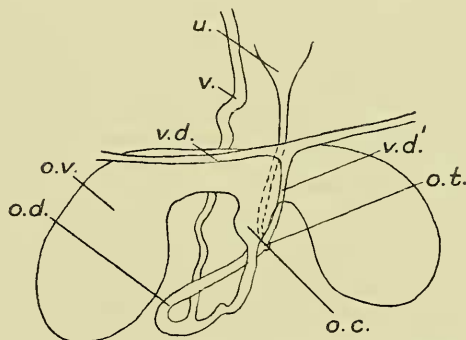


Diagram of the female genital ducts. *o.c.*, oöclapt; *o.d.*, oviduct; *o.t.*, oötype; *o.v.*, ovary; *v.*, vagina; *v.d.*, vitelline duct; *v.d'*, common vitelline duct; *u.*, uterus.

Leading from the connecting-bridge of the ovaries is the oöclapt or "Schluckapparat" (Pl. II. fig. 14). This is a nearly spherical muscular organ, $\cdot 002$ mm. broad $\times \cdot 0022$ mm. long, with a lumen of $\cdot 008$ mm. dia. Its cavity is lined by cubical epithelium according to Benedict, but with simple cuticle according to Kraemer; the latter is the case with my specimens. The muscular band surrounding it is hemispherical in transverse section and constitutes the greater part of its walls. An irregular ring of nuclei surrounds it externally.

Into the oöclapt opens the oviduct. This is a short tube

going to the posterior margin of the proglottis, where it is joined by the vagina, and then, bending at an angle of 30° , it runs anteriorly to open into the oötype just under the oöclapt. Its wall consists of an outer epithelium, a muscular layer, and a thick layer of ciliated cubical epithelium, the wall being $\cdot 0034$ mm. in thickness, surrounding a lumen $\cdot 009$ mm. dia. At its opening into the oötype the lumen of the oviduct decreases to $\cdot 003$ mm. dia.

Benedict states that gland-cells are scattered along the external epithelium, but I have been unable to see them.

The oötype (Pl. I. fig. 11) is a rounded body, $\cdot 014$ mm. dia., with walls $\cdot 0029$ mm. thick, composed of an inner non-ciliated epithelium, a circular muscular layer, and an outer epithelium; round it are scattered nuclei, $\cdot 0011$ mm. dia., not arranged in definite rows as Kraemer states. Surrounding the oötype and opening into it by fine ducts are shell-glands of irregular shape and with definite nuclei. Benedict represents the oötype as an elongated tube between the opening of the common vitelline duct and the uterus: in the position mentioned there is certainly a duct which appears, as he says, like a specialised portion of the oviduct, but this is not the oötype.

The vitellaria consist of small follicles scattered along the whole length of the lateral margins of the proglottis. The follicles are $\cdot 0092 \times \cdot 0069$ mm. in transverse section, with a distinct nucleus, $\cdot 0034$ mm. dia., and are grouped together in fours or fives, each group being enclosed in a membranous sac $\cdot 03$ mm. dia. Two longitudinal ducts, one on each side, run down the proglottis, receiving numerous fine ducts from the sacs, to its hinder end, where they turn inward and join to form a common duct. This duct runs longitudinally for a short distance to open into the oötype. It has a lumen $\cdot 0029$ mm. dia., with walls $\cdot 0023$ mm. thick, consisting of inner and outer epithelia surrounding a well-developed circular muscular coat: connective tissue nuclei form a definite layer round it.

The uterus passes as a narrow tube from the oötype under the connecting portion of the ovaries, and expands as a large sheet with 6–10 lateral outgrowths along the ventral surface of the proglottis (Pl. I. fig. 8). In older segments, the uterus fills the entire segment to the exclusion of all other organs. The ova escape through a cleft in the mid-ventral line.

LIFE-HISTORY.

Historical.

The life-history of this species is unknown. Von Siebold (24) states "le *Tænia longicollis* et le *T. ocellata* qu'on rencontre enkystés, hors du canal intestinal, dans la foie de divers Salmones et Percôides:" the fish are swallowed by pike or perch, in the intestine of which the parasite becomes adult. In

another work (23) he announced definitely that the larval forms of *T. longicollis* and *T. ocellata* occur encysted, with non-mature unsegmented bodies, in the livers of salmon and perch.

Zschokke (26) found the unsegmented larva of *T. longicollis* in *Salmo umbla*.

Similarly, von Linstow (14) states, "Die Larva findet sich encystiert in der Leber desselben Fische, welche die erwachsene Tänie in ihrem Darm beherbergen."

Lühe (17) also inclines to this view. "Als zugehörige Larve ist eine in der Leber von Perciden encystiert gefundene Cestoden-Larva betrachtet werden (?)."

"Leuckart (13) reports a plerocercus found by Gruber in *Cyclops serratulus* which he believed to be the larva of *Proteocephalus torulosa* Batsch. From a comparison of his figure, which is drawn to scale, with measurements of *P. torulosa*, it seems that there is some foundation for this view" (La Rue (12)). To this larval host Lühe (17) adds *C. strenuus*.

It may be seen from the above summary that no accurate experiments have been made with this genus. Most of the investigators incline to the view that the larvæ occur in the same host as the adult form, basing their opinion upon comparisons of the size and general shape of both forms. The connection is thus very loose. The infection would have to be by means of eggs. As there is no swimming-mantle, these do not float, but sink to the bottom; and since the sticklebacks in Edgbaston Reservoir feed chiefly upon Entomostraca, the comparative rarity with which they would swallow eggs could not account for the heavy infection observed. Moreover, the onchosphere would have to bore its way through the walls of the alimentary canal to the liver, encyst there, and then return to the alimentary canal again; for there could be no other way for it to infect both the liver and the intestine of the same host. This hypothesis is not very plausible and is not very well supported. At different times I have examined the livers of sticklebacks but without finding any trace of cysts, although nearly all the stages have been found in the alimentary canal.

My own researches point to the conclusion that an intermediate host, *Cyclops varius* Lillj., is necessary for the full development of the egg, and it is through the final host swallowing the intermediate host, that the parasite obtains entrance to the alimentary canal of the former. This view is supported by the discovery of the plerocercoid of *P. torulosa*, previously mentioned*.

Infection Experiments.

In studying the life-history of this parasite, I first began with the eggs. If the Cestode be adult or nearly so, directly it is removed from the intestine of its host, it begins to discharge the eggs in a continuous stream from a slit in the ventral body-wall.

* See Note on pp. 137-138.

These were pipetted into a small watch-glass, water (pond or tap) was added, and they were examined every day for about two months. It was assumed that water would be the natural medium for their development, since under ordinary circumstances they would be expelled into the pond and wait there until swallowed by their first host. Altogether 20 cultures were thus made and kept from the middle of October until the end of January, but with no results. The most advanced stage was that shown in Pl. III. fig. 23, but this was also observed in eggs taken freshly from a living specimen. Cultures were also made in salt solution, peptone, albumen, and faecal matter, different strengths being used, but with no result.

While these cultures were going on, examples of the most common invertebrates in the reservoir (various species of *Cyclops*, *Cypris*, *Nais*, and *Tubifex*, together with some unidentified Entomostraca and numbers of aquatic insect larvæ) were collected. They were placed in small dishes, each species being kept separately and in definite numbers. A certain amount of Diatoms, *Euglenæ*, Algæ, etc., was placed in each dish for food, together with a large quantity of eggs. No results were obtained until Jan. 7th, when, after examining a *Cyclops*, the cover-glass accidentally crushed it; on re-examining it, several tapeworm eggs were seen in the crushed-out body-mass. All the cultures were then, and for some days afterwards, minutely re-examined, but eggs were only seen in the *Cyclops*.

A fresh series of cultures was made with *Cyclops* from three localities to test this result, with a control to each culture. As was expected, the controls only gave negative results. The other cultures turned out better than was expected (see Table C): as many as 17 out of 20 *Cyclops* in one case were infected, while there were some infected *Cyclops* in every culture. The figures do not represent the whole truth, however. It is extremely difficult to keep the *Cyclops* alive under these artificial conditions; in one culture 4 out of 15 died in one week, in another 2 out of 6, in another 3 out of 7, etc.

Schneider (22) found that in his infection experiments, feeding *Gammarus locusta* with eggs of a species of *Proteocephalus*, the *Gammarus* died in large numbers owing to too heavy infection: this may account for the death of some of the *Cyclops*, since as many as six larvæ in one specimen have often been seen. As it is impossible to distinguish onchospheres in dead *Cyclops*, those dead cannot be counted. (In parenthesis, it may be said that the eggs appear to secrete a toxin which acts injuriously on other animals in the small culture dishes, but which, in the large volume of water in the reservoir, would be diluted until it would become negligible. In one instance a culture was started in a dish containing 20 *Cypris*, some *Euglenæ* for food, and some of the Cestode eggs; a control of the same number of *Cypris* was placed under identically the same conditions, except that the eggs were absent. In 18 days all the *Cypris* in the first culture were dead; in the control I counted 220 living

TABLE C.

Culture.	N ^o . of Cyclops.	Locality.	Number Infected each time.														Total No. Infected.	
			January.							February.								
			10	15	16	18	20	22	23	27	28	3	4	7	10	11	20	27
1 X C.	13	Edgbaston.	S	4	...	...	...	...	...	...	...	1	...	...	...	...	...	...
1 Y C.	20	"	S	4	1	...	2	...	...	3	...	2	...	...	...	...	...	...
*2 Y C.	8	"	S	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1 Z C.	10	Wolverhampton.	...	...	...	S	1	...	...	3	...	...	...	...	2	...	...	...
2 X C.	20	King's Norton.	...	...	...	...	...	S	...	...	11	...	1	3 added	...	...	1	...
3 X C.	20	"	...	...	...	...	...	S	...	...	3	...	2	...	...	1	...	...
3 Y C.	20	Edgbaston.	...	...	...	...	...	S	...	...	17	...	...	...	...	...	...	...
2 Z C.	20	King's Norton.	...	...	...	...	...	...	S	...	1	...	2	...	...	...	...	...
	134		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	64

Percentage infected 47.

* Cestode eggs not mature.

S=started.

Cypris. In all cases the animals in the control lived longer than those in the experimental dishes.) Moreover, no attempt was made to discriminate between the different species of *Cyclops*, since the species infected was not known. Under the most favourable conditions it is extremely difficult to see the eggs in the host, so that, owing to the opacity of the body and the development of the dense black ovaries, many probable cases of infection have been overlooked. The results were therefore as good as might be expected.

The intermediate host is therefore a species of *Cyclops*, which Professor G. S. Brady has kindly identified for me as *C. varius* Lilljeborg.

In this connection it may be said that the younger *Cyclops* appear to be more easily and more heavily infected than the adults; the nauplii, however, are never infected.

In addition to these culture experiments, large numbers of Entomostraca, Oligochaeta, and aquatic insect larvæ from the reservoir have been examined at various times. In the winter and early spring no traces of infection were found, although it is quite possible that they may have been overlooked. In June, however, out of 117 *Cyclops* taken at random, 8 were found to be infected, and 3 out of the 8 contained larvæ ready to be transferred to the stickleback. This agrees with Kraemer's (10) statement that the life-history takes place in the summer months, and with the fact that the percentage of adult *Ichthyotenia* is greatest at that season. The small percentage of infected *Cyclops* found can be easily explained by the fact that the 117 specimens examined contained examples of many species, but out of these only *C. varius* could be infected. By examining the contents of the alimentary canal of the stickleback, it was ascertained that in summer they fed chiefly upon Entomostraca, so that a very small percentage of infected *Cyclops* would be sufficient to ensure a heavy infection of sticklebacks. It would thus be quite easy to overlook this occasional infection unless one were very familiar with the appearance of the larvæ.

In order to complete the life-cycle of the parasite, an experiment was started to infect the stickleback. This was a failure. A number of sticklebacks were obtained from the same pond, and about 20 were dissected: not one of them showed any trace of the parasite. Ten of them were then isolated and fed occasionally with chopped-up earthworms and infected *Cyclops*; a control experiment was started under the same conditions, except that only earthworms were used for food. The experiment lasted from April 25th to May 16th. From time to time some fish died, but no trace of the Cestode was found in either those from the experimental jar or those from the control. On May 7th, for the first time, a small unsegmented *Ichthyotenia* was found in the intestine of a dead fish; it was obviously in an exceedingly young stage. On May 16th the rest of the fish were dissected, but without finding any Cestodes.

The failure of this experiment was probably due to the small number of *Cyclops* with which the fish were fed (owing to various causes it was difficult to get infected *Cyclops* at the time), the short time between the feeding of the fish and their dissection, and the small size of the larvæ.

The experiment was then repeated, particular attention being paid to the above points, and this time there was success. It began on May 27th, when 11 sticklebacks from the same pond were fed with about 20 infected *Cyclops*. The following results were obtained:—

DATE.	Number Dead.*	Larvæ in each.	Number Infected.
June 4th.....	4	0, 4, 7, 1	3
„ 6th.....	3	0, 0, 4	1
„ 7th.....	1	2	1
„ 30th.....	1	1	1
July 1st	2	8, 1	2
	11	28	8

A control experiment of five sticklebacks was started at the same time and gave a negative result.

In order to test the possibility of direct development, an experiment was started on June 12th. Nine sticklebacks were isolated and fed with large quantities of adult proglottides of the Cestode; in addition, a large number of eggs was put into the water. The experiment lasted until July 16th, when the surviving sticklebacks were dissected. None of the nine, however, showed the slightest trace of infection, either in the liver or in the intestine.

As a further test, thirteen sticklebacks from the reservoir were isolated and kept for about six weeks. They were then dissected, but the only trace of infection found was a nearly adult cestode in the intestine of one of them. It is practically certain, considering the heavy percentage of infection, that at least half these were infected at first; the worms must therefore have been ejected and have shed their eggs into the water. If direct infection occur, then the sticklebacks should have been re-infected, but since no infection was found, the conclusion is that direct infection does not take place. La Rue (11), in attempting to show direct development in *P. filaroides* from the salamander, failed to infect the salamander itself with eggs of the Cestode, although in his case the conditions were certainly not very favourable.

* Both in this, and in the following experiments, a fungus (*Saprolegnia ferox*) obtained entrance to the experimental jar and killed the fish, so that the adult Cestode could not be bred.

Development.

The development of the egg has not been fully worked out, but the results so far show a close similarity to those of van Beneden (2), who used *Tenia serrata*.

Both fresh and stained material have been used; the results obtained by the use of the former give a connected series, but there are gaps between the stages observed in stained material.

Kraemer (10) appears to be the only investigator who has described the several stages in the development of the egg, but my own material does not agree at all with his description.

The following results were obtained from fresh unstained material.

When the eggs pass into the uterus, they appear to consist of a transparent colourless membrane, .021 mm. dia., containing a roughly spherical mass of uniform refractive grey yolk-granules; this inner mass lies freely within the membrane, which only touches it at one or two points. Both the membrane and the inner mass increase in size, but the former more rapidly than the latter, so that later on, the impression given is that of a grey ball, .025 mm. dia., within a large bubble .047 mm. dia. (Pl. II. fig. 15). From this point the membrane always preserves the same relative distance between it and the inner mass, and finally becomes the outer membrane of the onchosphere (*m.*). The yolk-follicles now begin to disappear, clustering together at one pole, the remainder of the inner mass being filled up by a fine grey granular substance, from which the onchospheric hooks appear to originate.

Meanwhile the inner mass has become differentiated into a central mass, .023 mm. dia.—the future onchosphere—within an outer granular coat, .028 mm. dia. and .002 mm. thick (Pl. II. fig. 17), which at first touches it at every point, but later shrinks away to leave the onchosphere entirely free. By the time the yolk-follicles have disappeared the egg has become ready for discharging (Pl. II. fig. 19). It then consists of the onchosphere, .023 mm. dia., provided with six hooks, and closely surrounded by a delicate membrane. This is surrounded by the granular second membrane (*m'*), .035 mm. dia. and .002 mm. thick, the whole free within a transparent membrane (*m.*), .058 mm. dia. The hooks are .011 mm. long, .001 mm. at their broadest part, and the curved part is .004 mm. long. Treatment with a solution of methyl green in 1 per cent. acetic acid shows that the second membrane has a circular hole, .0057 mm. dia., in it.

Sections of the cestode killed with Petrunkevitch's solution and stained with iron hæmatoxylin give the best detailed results.

The ovarian eggs (Pl. III. fig. 24) are .017 mm. dia., very granular, and are surrounded by a distinct membrane. A clear nucleus, .0092–.0103 mm. dia., is present, containing a dark-

staining nucleolus, .0057-.0069 mm. dia.; often granular strands connect the nucleolus to the nuclear membrane. In addition, there is a dark-staining "Nebenkörper" or "corps lenticulaire" of irregular shape and indefinite size. It seems to disappear before the first division and is of unknown significance. Von Linstow (14) has figured a similar body in the eggs of *Tenia longicollis* Rud.

The first division of the fertilised egg (Pl. III. fig. 25) is into a vitelline cell crowded with yolk-granules and a "Keimzelle," with nucleus and nucleolus. Kraemer for *T. filicollis*, and von Linstow for *T. longicollis*, figure the vitelline globules as isolated, not as being contained in a single cell.

The "Keimzelle" next divides into two, and each of these into two again, four cells of equal size being formed (Pl. III. fig. 29), .012 mm. dia., with nuclei .005 mm. dia. In van Beneden's account, these cells are of unequal sizes, two large macromeres forming the "couche albumineuse," and two small micromeres forming the onchosphere with its membranes and hooks. In this case there is certainly a "couche albumineuse" formed (Pl. III. fig. 31), although as the four cells are identical, it is impossible to distinguish those from which it arises. The remaining cells divide repeatedly, forming a cellular mass, the nuclei of which are of two sizes:—

- (1) nucleus .0057-.0069 mm. dia., nucleolus .0023-.0034 mm. dia.
- (2) " .004-.0046 " " " .0011 mm. dia.

The cells containing the larger nuclei surround the others and a split appears between the two (Pl. III. fig. 30). This gradually widens until the first cells form a definite coat—the second onchospheric membrane—round the smaller ones (Pl. III. fig. 32). It is thus probable that the former correspond to van Beneden's "Chitinogenzellen." The origin of the hooks and the third onchospheric membrane I have not been able to discover.

The vitelline cell, produced by the division of the ovarian egg, does not exist long as a distinct cell, and soon degenerates into a mass of yolk-follicles. It is these follicles which scatter when the onchosphere breaks through the second membrane (Pl. III. fig. 23).

At the time of discharge, the onchosphere is formed of a number of spherical cells, .0057 mm. dia., with distinct nuclei, .0034 mm. dia., the cells at the posterior end being slightly larger than those at the anterior.

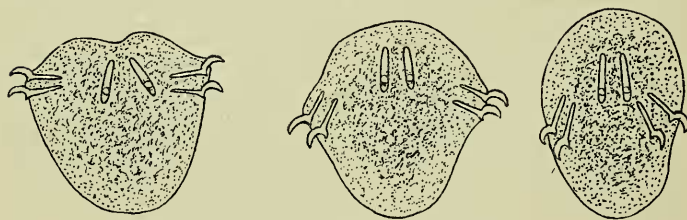
When the contents of the majority of the proglottides are ready for discharging, the Cestode slightly migrates through the intestine, probably by the contractions of the latter, and hangs out of the anus. The eggs are then expelled from the uterus through a slit caused by a rupture of the ventral body-wall. When the contents of the exposed proglottides have been discharged, the body hangs further out, exposing more segments, until all the ripe eggs have been extruded. If stickle-

backs infected by this parasite be kept in an aquarium, it is no uncommon sight to see them with $\cdot 5''$ - $\cdot 2''$ of cestode hanging out of the anus. The proglottides first emptied degenerate, and all traces of segmentation become obliterated, until by the time the last eggs are discharged, the distal end has become an unrecognisable shapeless mass. The whole cestode is then discharged with the faeces, and this is often followed by the death of the fish.

Some time after entering the water, the onchosphere escapes through the hole in the second membrane to lie freely inside the outer one. Since the diameter of the hole is less than that of the onchosphere, the latter is considerably contracted in its passage: the third membrane is often dragged out with it, but it may be ruptured and left behind. The cause of this escape may be possibly due to osmosis, but it is more probable that it is due to the onchospheric movements about to be described. The posterior portion of the onchosphere is always under the aperture in the second coat, so that the movements would have a ramming effect upon the delicate third membrane, and either rupture it or drag it out. The pressure of the coverslip is not the cause, for I have often seen similar movements in onchospheres lying freely in a watch-glass. Yolk-follicles are often scattered within the membrane at the time of the escape.

The onchosphere now exhibits curious movements (I have only seen them in the free onchosphere, but it is probable that they occur also before the escape takes place). It slowly contracts

Text-figure 5.



Drawing to show movements of onchosphere.

antero-posteriorly, stretching out its hooks as far as possible; the extreme anterior point often forms a small depression surrounded by a ridge. With a quick jerk it elongates itself along the same line, at the same time striking downwards with its hooks until they lie flat against the body. It then contracts as before. The movements are repeated indefinitely, and are probably for the ultimate purpose of attaching the onchosphere to the alimentary canal of its host.

La Rue (11) reports similar movements in the onchospheres of

P. filaroides. In this case though, the movements of two pairs of hooks alternate with those of a third pair, and the body changes from a spherical to a pear-shaped form. He also saw these movements in onchospheres of *Hymenolepis nana*.

At this stage the onchosphere is swallowed by a *Cyclops*. It appears to pass through the stomach and first portion of the alimentary canal without any change or delay, and although it generally anchors itself to the wall about the junction of the thorax and abdomen, I have seen cases where it has attached itself to the wall of the alimentary canal just within the stomach on the one hand, and just above the anus on the other, but these are not common. After a certain time has elapsed, the extent of which is very variable but is usually a week, it breaks through the wall of the intestine into the dorsal sinus and is swept forward to lie usually near the posterior end of the carapace, but often in the head above the eye; it may also lie under the alimentary canal, but this is rare. Here it becomes very vacuolated at first, but later has a more solid appearance (Pl. IV. fig. 33). The hooks gradually disappear, and the body becomes partially covered with highly refractive granules, either isolated or disposed in clusters. These granules greatly resemble those found on young larvæ in the intestine of the stickleback, except that they are smaller.

At the end of three weeks the larva is ready to be transferred to its second host (Pl. IV. fig. 37). It is an elongated grey body of variable size, and *in situ* seems to be an undeveloped part of the ovary. It is apparently studded with the refractive granules just mentioned, .004 mm. dia., which give it a characteristic appearance when removed from the *Cyclops*. In sections it may be seen that these really occupy spaces in the body parenchyma just under the cuticle and correspond to the calcareous bodies of older forms. There is no scolex and no neck, the body being entirely without divisions. At the anterior end are four suckers, .03 mm. dia., which look like small blisters of the cuticle; they are probably functionless at this period. In sections they are practically level with the rest of the body. They are composed of the same parenchyma as the rest of the body (Pl. IV. fig. 35) only in a more compact form, and have two dark-staining types of cell. The first type is elongated, .005–.007 × .001 mm. It is present only in larvæ in an advanced stage of development, and is probably an embryonal muscle-cell. The other type is the same in size and form as the cells of the parenchyma. In younger cases the suckers appear like the rest of the parenchyma, from which, in transverse sections, they are only separated by a thin line. There is no trace of the fifth sucker. The scolex is not invaginated at any time during the development; it appears as if it were gradually differentiated from the body parenchyma at an early stage.

The whole body is covered by a cuticle, extending also over the suckers and excretory pore (Pl. IV. fig. 36). Its outer layer

is rough and ragged like that of the adult. Under it is a smooth homogeneous layer, .0018-.0029 mm. thick. Owing to the small size of the larva I have been unable to find any definite traces of muscles. Muscles must undoubtedly be present, however, for the larva is capable of sluggish contractions similar to those of the adult.

The body within the cuticle is a nearly solid mass of parenchyma. Just inside the cuticle the parenchyma forms a fairly compact sheath, but in proportion to its distance from the exterior it loses this compactness and becomes vacuolated, the centre itself being a fairly loose meshwork like that of the adult. The parenchyma between the suckers is firmer than that elsewhere. The parenchyma itself is a faintly staining granular mass, forming a more or less definite meshwork through which dark-staining cells are scattered (Pl. IV. fig. 35). It is not probable that these are nuclei owing to their comparatively large size, .003-.005 mm. dia.; inside them are often several darker staining bodies. In addition to these are smaller bodies like the former only smaller, .0016-.0025 mm.; they are also present in young suckers, and may possibly be nuclei. Occasionally circular granular bodies, .004 mm. dia., not so deeply staining as the others, are to be seen. These I take to be the refractive granules (calcareous bodies) apparently present on the surface of the larva. Running in all directions through the parenchyma are delicate fibres, which may possibly be the rudiments of muscles. It is exceedingly difficult to state the histological significance of all these different structures owing to their small size and general indefiniteness.

At the posterior end of the larva is a small depression running .016 mm. into the body, its apex expanding into an oval chamber, with its long axis parallel to that of the larva (Pl. IV. fig. 36). On all sides but one, this invagination is enclosed by the body, but on the fourth side it appears to be open to the exterior; if seen from this side, it shows the entire depression—in shape like the gullet and buccal groove of *Paramœcium*—which is not visible from the other side (Pl. IV. figs. 39, 40). The cuticle covers its exterior, so that it is a true invagination. Presumably this corresponds to the heart-shaped bubble in which, according to Kraemer, the longitudinal excretory canals open. I have been unable to see any signs of excretory organs, however.

There are no traces of reproductive organs in such a young stage.

The presence of the larva is fatal to the *Cyclops*, apparently causing its starvation. The orange globules usually present in the head of the *Cyclops* vanish, and the ovary degenerates and dwindles to half its usual size. The activity of the *Cyclops* also suffers; it does not swim so rapidly and takes much more frequent and longer rests than its fellows. Ultimately it dies. This sluggishness and death would be favourable to the larva, for

it would result in the easier capture of the *Cyclops* by the stickleback, and thus ensure the larva a better chance of attaining maturity.

The *Cyclops* is swallowed by the stickleback, and in the intestine of the latter the larva is set free to grow into the normal adult.

SUMMARY.

1. The paper contains a description of a tapeworm parasitic in *Gasterosteus aculeatus* Artedi. I regard this tapeworm as *Ichthyotenidia filicollis* Rud., though the absence of an adequate description of the species and the confusion into which the nomenclature has fallen, make the identification a matter of considerable difficulty. The synonym, *Proteocephalus* Wein., used by La Rue (12), does not seem to me justifiable.

2. An account is given of the anatomy and histology of the species. With the exception of one or two details, this account agrees closely with that given by Benedict (3) and by Kraemer (10).

3. Though many conjectures have been made with regard to the life-history of *I. filicollis*, no reliable information has hitherto been published. The evidence given in this paper shows that *Cyclops varius* Lillj. is the intermediate host. This conclusion is based upon successful experiments to infect the *Cyclops* by the tapeworm egg, and to infect the stickleback by the larva in the *Cyclops*. Direct infection of the stickleback proved impossible.

4. A short account is given of the segmentation of the egg and the development of the larva. Though incomplete in some respects, it was found that it followed the general course described by van Beneden (2).

LITERATURE.

- (1) BELLINGHAM.—Annals of Nat. Hist. vol. xiv., 1844.
- (2) BENEDEN, E. VAN.—“Recherches sur le développement embryonnaire de quelques Ténias.” Arch. de Biol. vol. ii. 1881; Journ. R. Micr. Soc. vol. i.
- (3) BENEDICT, H. M.—“On the Structure of Two Fish Tapeworms from the genus *Proteocephalus* Weinland, 1858.” Journ. Morph. 1900, vol. xvi. No. 2.
- (4) BLAINVILLE.—Dict. des Sci. Nat., t. lvii. p. 552.
- (5) BRAUN, M.—Vermes. Abt. 1 b. Cestodes, in Dr. H. G. Bronn's “Klassen und Ordnungen des Tierreichs.” Leipzig, 1900.
- (6) COBBOLD.—Transact. Linn. Soc. xxii., 1856.
- (7) DIESING, C. M.—“Systema Helminthum.” Vienna, 1850, vol. i.
- (8) DUJARDIN, F.—“Histoire Naturelle des Helminths ou Vers Intestinaux.” Paris, 1845.

- (9) KIESSLING, FR.—“Ueber den Bau von *Schistocephalus dimorphus* Crepl. und *Ligula simplicissima* Rud.” Arch. f. Naturgesch. 48. Jahrg. 1 Bd., 1882.
- (10) KRAEMER, A.—“Beiträge zur Anatomie und Histologie der Cestoden der Süßwasserfische.” Zeitschr. f. wissen. Zool. Bd. 53, pp. 647–722.
- (11) LA RUE, G. R.—“On the Morphology and Development of a new Cestode of the genus *Proteocephalus* Weinland.” Studies from the Zool. Lab. of the Univ. of Nebraska, No. 95, 1909.
- (12) LA RUE, G. R.—“A Revision of the Cestode family Proteocephalidae.” Zool. Anz. Bd. xxxviii., Nov. 1911.
- (13) LEUCKART, R.—“Die Parasiten des Menschen,” 2 Aufl. Leipzig u. Heidelberg, 1879–86.
- (14) LINSTOW, O. VON.—“Ueber den Bau und die Entwicklung von *Tenia longicollis* Rud.” Jena. Zeitschr. 1891, Bd. xxv.
- (15) LÖNNBERG, E.—“Ueber eine neuer Tetrabothriumspecies und die Verwandtschaftsverhältnisse der Ichthyotænen.” Central. f. Bakt. u. Parasit. 1894, vol. xv. No. 21.
- (16) LÜHE, M.—“Zur Kenntnis einiger Distomen.” Zool. Anz. Bd. 22.
- (17) LÜHE, M.—Cestodes, Heft 18, in Dr. Brauer’s “Die Süßwasserfauna Deutschlands.” Jena, 1910.
- (18) MONTICELLI, F. S.—“Notizie su di alcune specie di *Tenia*.” Boll. Soc. di Natural. in Napoli, Ser. I., Ann. 5, vol. v. 1891, fasc. 2.
- (19) RAILLIET.—Centralb. f. Bakt. u. Paras. Bd. xxvi., 1899.
- (20) RIGGENBACH, E.—“Das Genus *Ichthyotenia*.” Inaugural-Dissertation, Geneva; Revue Suisse de Zool. 1896, Bd. iv.
- (21) RUDOLPHI, E. A.—“Entozoorum sive Vermium Intestinalium Historia Naturalis,” vol. iii. Amsterdam, 1810.
- (22) SCHNEIDER, G.—“Beiträge zur Kenntniss der Helminthenfauna des Finnischen Meerbusens.” Acta Soc. pro Fauna et Flora Fenn. xxvi. No. 3, 1904.
- (23) v. SIEBOLD.—“Ueber die Band- und Blasenwürmer.” Leipzig, 1854.
- (24) v. SIEBOLD.—“Mémoire sur les Vers rubannés et vésiculaires de l’homme et des animaux.” Annal. des Sci. Nat. 1855, t. iv.
- (25) WEINLAND, D. F.—“Human Cestoides. An essay on the Tapeworms of Man, etc.” Metcalf & Co., Cambridge, Mass., 1858.
- (26) ZSCHOKKE, F.—“Recherches sur l’organisation et la distribution zoologique des Vers parasites des poissons d’eau douce.” Arch. de Biol. t. v., 1884.

EXPLANATION OF THE PLATES.

PLATE I.

- Figs. 1-7. Series of scoleces, showing variation in shape and size. Fig. 3 is the normal form. $\times 125$.
- Fig. 8. Optical section of a proglottis. *c.s.*, cirrus-sac; *g.s.*, genital sinus; *l.c.*, longitudinal excretory canal; *ov.*, ovary; *v.*, vagina; *vas.*, vas deferens; *vit.*, vitellaria; *u.*, uterus. $\times 185$.
9. Longitudinal section of cirrus-sac. *c.m.*, circular muscles; *e.w.*, outer, and *i.w.*, inner wall of cirrus-sac; *l.m.*, longitudinal muscles; *r.m.*, retractor muscles; *vas.*, vas deferens. $\times 590$.
10. Transverse section of cirrus-sac, lettering as above. *c.g.*, gland. $\times 870$.
11. Longitudinal section of oötype. *o.d.*, oviduct; *O.T.*, oötype; *Sh.G.*, shell gland; *u.*, specialised part of uterus. $\times 870$.

PLATE II.

- Fig. 12. Longitudinal vertical section through cuticle. *c.*, *c'*, outer and inner layers of cuticle; *c.c.m.*, circular, *c.l.m.*, longitudinal cuticular muscles; *i.l.m.*, inner longitudinal muscles; *i.s.*, intercellular space; *p.c.*, cell of parenchyma; *s.c.*, cell of sub-cuticula. $\times 600$.
13. Longitudinal section through vaginal aperture. *s.m.*, sphincter muscle; *v.e.*, vaginal epithelium; *v.g.*, vaginal gland; *v.m.*, vaginal muscle. $\times 870$.
14. Longitudinal section through oöclapt. *c.e.*, cubical epithelium of oviduct; *o.e.*, outer oviducal epithelium; *o.m.*, oviducal muscle; *ov.*, ovary; *ov.b.*, connecting part of ovaries; *s.d.*, muscle of oöclapt. $\times 870$.
- Figs. 15-19. Stages in the development of the egg. *m.*, first, *m'*, second onchospheric membrane; *o.*, onchosphere; *o.h.*, onchospheric hooks; *x.*, aperture in second egg-membrane; *y.*, yolk-follicles. $\times 870$.

PLATE III.

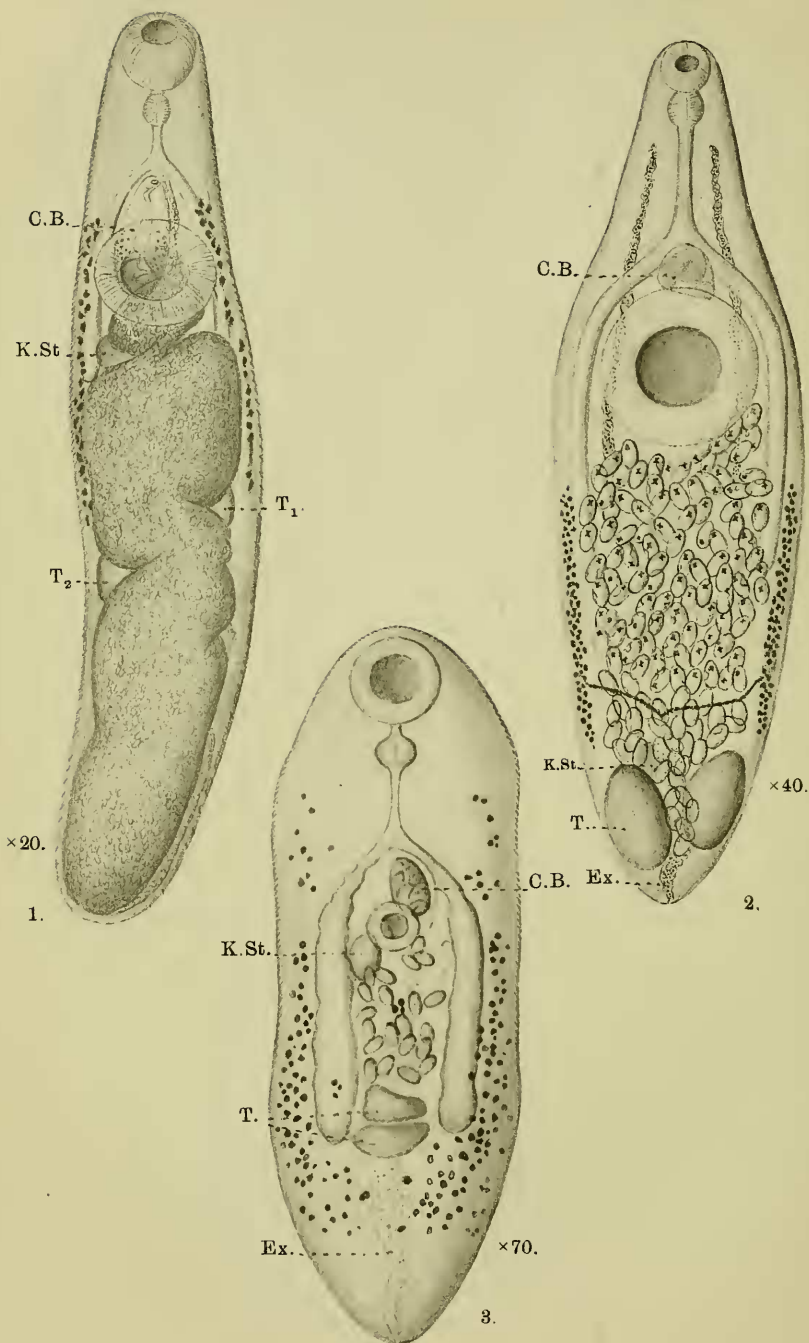
- Figs. 20-22. Stages in the rupture of the second onchospheric membrane. $\times 870$.
- Fig. 23. Onchosphere after rupture of second membrane. *m.*, *m'*, *m''*, first, second, and third onchospheric membranes. $\times 870$.
24. Eggs from ovary. *e.g.*, Egg membrane; *n.*, nucleus; *n'*, nucleolus; *n.k.*, "Nebenkörper." $\times 870$.
25. First division of egg. *k.m.*, "Keimzelle"; *m.*, first onchospheric membrane; *n.*, nucleus; *n'*, nucleolus; *v.c.*, vitelline cell. $\times 970$.
26. Later stage, showing division of "Keimzelle" nucleus. $\times 970$.
27. Stained section of fig. 26. $\times 870$.
28. Section of three-cell stage. $\times 870$.
29. Four-cell stage. Only three of the four products of "Keimzelle" division are shown. *v.c.*, vitelline cell. $\times 870$.
30. Section of older egg. *ch.*, "Chitinogenzellen"; *o.*, onchosphere; *sp.*, split between the two; *v.c.*, vitelline follicles. $\times 870$.
31. Older egg. *c.a.*, "couche albumineuse."
32. Section of uterine egg. $\times 870$.

PLATE IV.

- Fig. 33. *Cyclops varius*, containing young larvæ. *l.*, larvæ. $\times 50$.
34. Transverse section of the *Cyclops*. $\times 142$.
35. Longitudinal section through head of a larva from *Cyclops*. *c.*, *c'*, outer and inner layers of cuticle; *m.*, *m'*, the two types of parenchymatous cell; *o.g.*, space containing calcareous body; *s.*, sucker. $\times 870$.
36. Longitudinal section through posterior end of larva. *e.p.*, excretory pore. $\times 830$.
37. Larva from *Cyclops varius*. *s.*, sucker; *c.b.*, calcareous body. $\times 155$.
38. Larva from an artificially infected stickleback. $\times 95$.
39. Young larva from a stickleback. $\times 95$.
40. Older larva. $\times 95$.

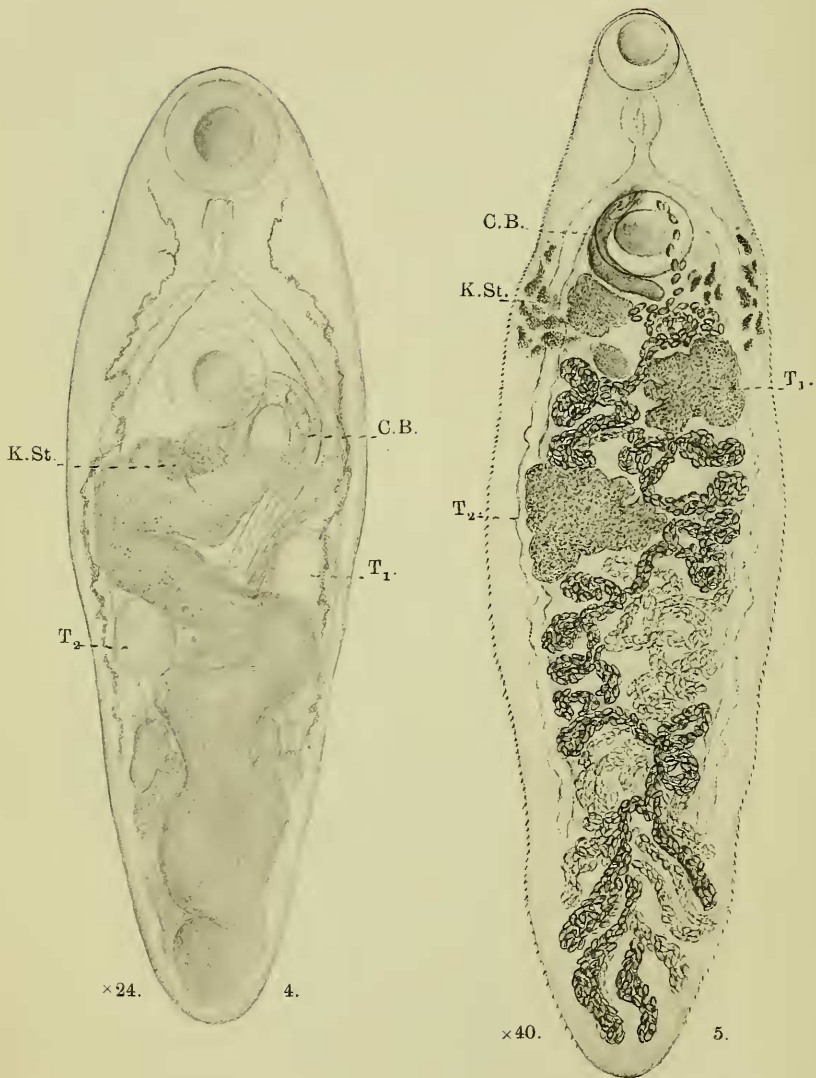
[NOTE.—Since sending in this paper, I have been able to obtain a copy of Barbieri's memoir (Central. f. Bakt. u. Paras., Abt. i.

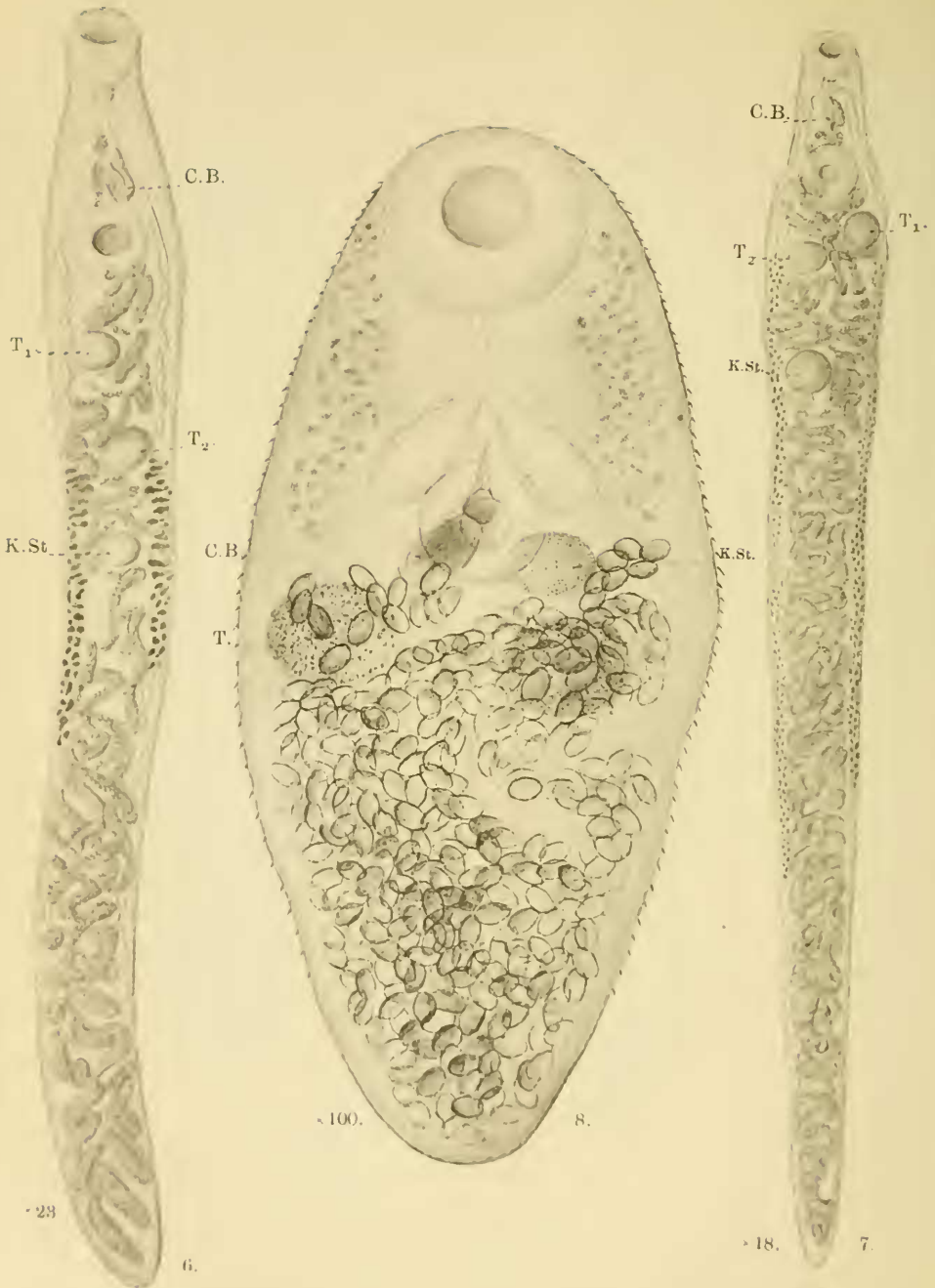
1909, Bd. xlix.), in which he records a cyst of *I. agonis* from the mandible of *Bythotrephes*; Fuhrmann also records from *Planaria lactea* a plerocercoid which he regards as that of a species of *Ichthyotenia*. These cases further strengthen the assumption that an intermediate host is necessary for the development of all species of *Ichthyotenia*.]



M. Rhodes, del.

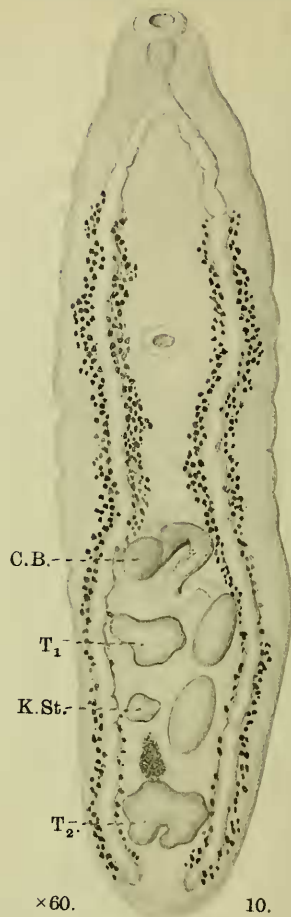
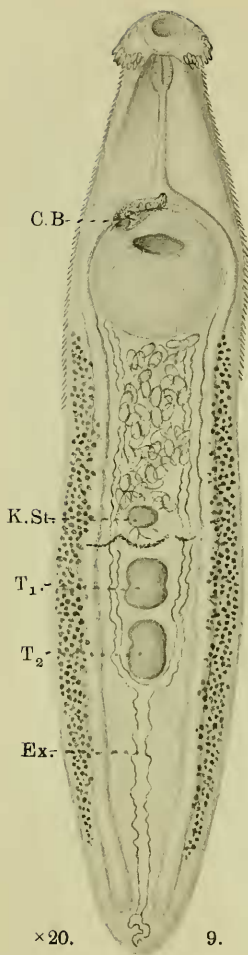
London Stereoscopic Co. imp.





M Rhodes and G Roberts, del

TREMATODE PARASITES



9. Trematode Parasites from Animals dying in the
Zoological Society's Gardens during 1911-1912. By
WILLIAM NICOLL, M.A., D.Sc., M.D., F.Z.S.

[Received November 3, 1913 : Read March 3, 1914.]

(Plates I.-IV.)*

	Page
ETHOLOGY :	
Trematode parasites from animals in London Zoological Gardens ...	139-154
GEOGRAPHICAL ZOOLOGY :	
North America : Striped Snake (<i>Tropidonotus ordinatus</i>); new trematode from intestine	140
North Africa : Spiny-tailed Mastigure (<i>Uromastix acanthinurus</i>); new trematode from intestine (7th Nov. 1911)	141
South America : Schott's Snake (<i>Philodryas schotti</i>); new trematode from intestine (10th Feb. 1912)	142
Europe : Asp Viper (<i>Viper aspis</i>); new trematode from intestine (7th June, 1912)	143
India : Indian River-Snake (<i>Tropidonotus piscator</i>); new trematode from intestine (4th December, 1911)	144
Moluccas : Purple-capped Lory (<i>Lorius domicella</i>); new trematode from liver (22nd November, 1911)	146
Guiana : Crested Curassow (<i>Crax alector</i>); new trematode from liver (26th Feb. 1912)	147
North America : Summer Snake (<i>Contia aestiva</i>); new trematode from intestine (7th July, 1911)	147
North America : Ruddy Flamingo (<i>Phenicopterus ruber</i>); new trematode from intestine (6th December, 1911)	148
West Africa : Smyth's Water-Snake (<i>Graglia smythii</i>); new trematode from intestine (May, 1912)	150
Egypt : Egyptian Eagle-Owl (<i>Bubo ascalaphus</i>); new trematode from intestine (24th October, 1911)	151
SYSTEMATIC :	
Family LEPODERMATIDÆ.	
<i>Mediorima propria</i> , gen. et sp. n., from intestine of Striped Snake	140
<i>Ommatobrephus singularis</i> , gen. et sp. n., from intestine of Spiny-tailed Mastigure	141
<i>Opisthogenes interrogativus</i> , gen. et sp. n., from intestine of Schott's Snake	142
<i>Opisthioglyphe adulescens</i> , sp. n., from intestine of Asp Viper	143
<i>Styphlodora persimilis</i> , sp. n., from intestine of Indian River-Snake	144
Family DICROCÆLIIDÆ.	
<i>Lyperosomum scitulum</i> , sp. n., from liver of Purple-capped Lory	146
<i>Lyperosomum direptum</i> , sp. n., from liver of Crested Curassow	147
<i>Brachyccelium obesum</i> , sp. n., from intestine of Summer Snake	147
Family ECHINOSTOMIDÆ.	
<i>Echinostomum aliud</i> , sp. n., from intestine of Ruddy Flamingo	148
Family CLINOSTOMIDÆ.	
<i>Harmotrema infecundum</i> , gen. et sp. n., from intestine of Smyth's Water-Snake	150
Super-family HOLOSTOMATA.	
<i>Hemistomum canaliculatum</i> , sp. n., from intestine of Egyptian Eagle-Owl	151
List of Hosts	152

During the course of 1911 and 1912 opportunity was afforded me of making a fairly complete examination of the viscera of many of the animals dying in the Gardens. For this I have

* For explanation of the Plates see pp. 153-154.

to thank the courtesy of the Secretary and the officials at the Prosectorium. The animals were almost exclusively birds and reptiles or batrachians; no fishes, and only a few mammals were examined. The collection yielded between twenty and thirty species, a considerable proportion of which are new. Some of these have already been described in previous communications to the Society (Nicoll, 1911, 1912, *a*, *b*).

The reptilian parasites were the most interesting of those obtained, as several of them represented new generic types. They include forms from the Striped Snake, the Spiny-tailed Mastigure, Schott's Tree-Snake, and Smyth's Water-Snake.

Usually there was an interval of twenty-four hours, sometimes longer, between the death of the animal and the time of examination, but in spite of that the parasites in most cases were in a good state of preservation. In some instances, however, they were so macerated as to be almost useless. As might have been expected, parasites were more frequent in those animals which had been in the Gardens for the shortest period. Except in the few instances reported by Dr. Leiper (1912), there appears to be little probability of infection being acquired in the Gardens. In most cases the infections were not heavy, there being usually only a few worms present. Gross infections, however, were met with in the case of some Striped Snakes which were heavily infected with two larval Trematodes (Nicoll, 1912), and a Marsh Harrier which contained a large number of liver-flukes.

The first form I shall describe is an interesting new species from the Striped Snake (*Tropidonotus ordinatus*).

Family LEPODERMATIDÆ.

1. MEDIORIMA PROPRIA, gen. et sp. n. (Pl. I. fig. 1.)

This species is a typical member of the family Lepodermatidæ, to which a large proportion of reptilian trematodes belong. One specimen was obtained from the intestine of a Striped Snake (*Tropidonotus ordinatus*).

It is an elongated, slightly flattened Trematode, both ends of which are rounded. The cuticle is beset with small spines, which extend throughout the whole length of the body. The length is about 6 mm., the greatest breadth, near the middle of the body, is 1.2 mm.

The globular oral sucker has a diameter of .5 mm.; the ventral sucker, which is somewhat oval, measures .7 × .8 mm., and is situated 1.7 mm. from the anterior end.

There is a very short prepharynx, and a pharynx measuring .2 × .17 mm. The œsophagus is about the same length as the pharynx. The intestinal diverticula are short, not extending very far (.4 mm.) beyond the ventral sucker. Their ends are obscured by the enormous mass of ova.

The genital aperture is median and is situated just behind the

intestinal bifurcation. The cirrus-pouch is short and stout, measuring $.8 \times .34$ mm. It is almost oval in outline. Within it there is a small convoluted vesicula seminalis, with a moderately long pars prostatica and a short ductus ejaculatorius. The vagina is somewhat shorter than the cirrus-pouch.

The small globular ovary is situated a short distance behind the ventral sucker on the right side and is largely concealed by the uterus. The anterior testis lies on the left about 1 mm. behind the ventral sucker, while the posterior testis lies a little further back on the right side. Both are almost entirely concealed by the uterus, so that their size and shape could not be determined. They are, however, apparently elongated oval in outline. The yolk-glands are scanty, consisting on each side of a little more than a single row of follicles external to the intestinal diverticula, and extending from midway between the genital aperture and the anterior edge of the ventral sucker to the level of the anterior testis.

The uterus fills up the greater part of the posterior two-thirds of the body. It consists of a narrow descending limb and a very greatly distended ascending limb, which is twisted into slight folds. The extremely numerous ova are dark brown in colour and measure $.039 \times .018-.020$ mm.

This species bears a very close resemblance to the genus *Lechrriorchis*, but is distinguished from it by the position of the genital aperture and the shape of the cirrus-pouch.

2. OMMATOBREPHUS SINGULARIS, gen. et sp. n. (Pl. I. fig. 2.)

A single specimen of this species was obtained from the intestine of the Spiny-tailed Mastigure (*Uromastix acanthinurus*). It presents several features of interest.

The length of the specimen, slightly pressed, is 2.73 mm., and the maximum breadth across the ventral sucker is .8 mm. The anterior part of the body is considerably attenuated, the posterior part is more rounded but terminates in a somewhat acute point. There are no cuticular spines.

The subterminal oral sucker has a diameter of .18 mm. and the ventral sucker measures .53 mm. The latter is situated at a distance of 1.06 mm. from the anterior end. Contiguous with the oral sucker is a large pharynx, measuring $.12 \times .14$ mm. This is followed by a long oesophagus, .31 mm. in length. The intestinal bifurcation takes place a little in front of the ventral sucker, and the short diverticula terminate about midway between the ventral sucker and the testes.

The excretory vesicle is Y-shaped with a short sinuous stem, bifurcating a little in front of the testes, and limbs extending nearly to the level of the pharynx.

The genital aperture is median, just over the intestinal bifurcation. The cirrus-pouch is stout and almost globular, lying almost entirely in front of the ventral sucker. Its length and diameter are about .2 mm. It is thin-walled and contains a thick

highly-convoluted vesicula seminalis with a short prostate and ductus. The testes lie alongside one another, almost at the posterior end of the body. They are slightly asymmetrical, the left being a little in advance of the right, and they are separated by a narrow fold of the uterus. They are elongated oval in outline and measure $\cdot35 \times \cdot22$ mm.

A little in front of the testes lies a small round ovary, somewhat on the right side of the middle line. The shell-gland complex is entirely obscured by the uterus. The yolk-glands are of restricted extent, being confined to the extreme edges of the body and extending only from the ovary to some distance behind the ventral sucker. The uterus fills up the whole of the middle of the body and sends a small loop down between the testes. The eggs are thin-walled and very transparent, and the majority of them contain a fully developed miracidium, the X-shaped eye-spots of which are very conspicuous. The eggs measure $\cdot095 \times \cdot056$ mm.

This form evidently belongs to the family Lepodermatidæ, but it is somewhat aberrant. Its most distinctive features are the unusual position of the genital glands and the precocious development of the miracidia, together with the large size of the eggs.

3. OPISTHOGENES INTERROGATIVUS, gen. et sp. n. (Pl. II. fig. 4.)

Five specimens of this parasite were obtained from the intestine of Schott's Snake (*Philodryas schotti*). In length they vary from 4.5 mm. to 6.2 mm. (pressed specimens); the average is 5.4 mm. The greatest breadth across the ventral sucker is 1.7 mm. The outline is almost fusiform, the posterior half being more attenuated than the anterior.

Both suckers are nearly globular, the oral measuring .64 mm. and the ventral .56 mm. In both cases the longitudinal diameter is usually slightly greater than the transverse. The ventral sucker is situated 1.74 mm. from the anterior end. There is a short prepharynx followed by a pharynx measuring $\cdot21 \times \cdot2$ mm. The œsophagus is slightly longer than the pharynx, .27 mm. The intestinal diverticula terminate some distance (about .6 mm.) from the posterior end of the body, but their ends are obscured by the dense mass of the uterus.

The excretory vesicle is long and wide. The median stem runs forward to near the ovary before dividing into the two short lateral branches. The vesicle, as well as the main collecting tubules, are clearly mapped out owing to the pigmented nature of their contents. A large number of fine branches are given off from the vesicle, and these form an anastomosing network throughout the whole body.

The cirrus-pouch has the shape of an interrogation mark, curving over the left posterior quadrant of the ventral sucker. Its proximal end lies a short distance behind the sucker, while the male genital aperture is 1 mm. behind the sucker and a little to the left of the middle line. The female aperture is separated

from the male but immediately behind it. The cirrus-pouch contains a highly convoluted vesicula seminalis, a short pars prostatica, and a long straight ductus and cirrus. The musculature of the pouch and of the cirrus is extremely well developed.

The anterior testis lies on the left side, near the genital aperture. The second testis lies on the other side of the body, and is separated from the first by the uterus. The anterior border of the one is about .2 mm. in front of that of the other. Both are somewhat elongated oval in outline, their long diameter measuring .5-.65 mm. They are moderately thick and are not much overlapped by the uterus.

The ovary lies not far behind the ventral sucker, alongside the proximal end of the cirrus-pouch. It is globular and considerably smaller than the testes. It is usually difficult to see, owing to its being obscured by the uterus. Laurer's canal is present, but there is no receptaculum seminis. The initial part of the uterus is filled with sperms. The yolk-glands have an unusual disposition. Instead of being lateral they are entirely dorsal. Situated in the posterior half of the body, they extend from the level of the genital aperture to a short distance (.4 mm.) behind the testes. They consist of fairly large follicles which lie between the excretory vesicle and the cuticle, and which do not spread to the outer side of the intestinal diverticula.

Starting from the ovary, the uterus forms several small dorsal convolutions on its way towards the posterior end of the body. On turning forward it becomes greatly dilated. At first it runs almost straight forwards, then bends towards the left testis. Passing between the testes it forms a fairly large convolution in front of the right testis. It then passes across the ventral sucker and finally runs down along the left side of the cirrus-pouch. It overlaps the intestinal diverticula to a considerable extent. The vagina is a wide muscular structure about half the length of the cirrus-pouch. The ova are very numerous, dark brown in colour, and measure .020-.023 $\times$.013-.014 mm.

This species is most closely allied to *Opisthogonimus philodryochus* West, but it appears to present features of sufficient importance to warrant its being regarded as the type of a distinct genus. The chief distinctive features are the position of the genital aperture, the shape and structure of the cirrus-pouch, and the position of the yolk-glands.

4. OPISTHIOGLYPHE ADULESCENS, sp. n. (Pl. I. fig. 3.)

A few specimens of this form were taken from the intestine of an Asp Viper (*Vipera aspis*). They were all obviously immature, and on that account the following can only be regarded as a provisional description. For the same reason it is impossible to be absolutely certain that this form is distinct from the already known species of the genus, but one or two distinctive features seem to point to the fact that it is a separate species.

In shape it is elongated oval with somewhat pointed ends and almost parallel sides. The length is about 1·3 mm. and the greatest breadth ·46 mm. The cuticle is beset for at least three-quarters of the length of the body with minute spines. The oral sucker is subterminal and has a diameter of ·17 mm. The round ventral sucker is much smaller, measuring only ·10 mm., and it is situated at a distance of ·55 mm. from the anterior end of the body.

There is a short prepharynx, a pharynx measuring ·06 × ·08 mm., and a long œsophagus, twice the length of the pharynx. The intestinal diverticula are rather wide, and do not extend more than halfway between the ventral sucker and the posterior end of the body. The excretory vesicle is dilated and the median stem divides a short distance behind the ovary. The paired limbs only extend to the ventral sucker.

The genital aperture lies a short distance behind the intestinal bifurcation. The cirrus-pouch is short and plump, reaching only a short distance behind the anterior border of the ventral sucker. It contains a highly convoluted vesicula seminalis, a short pars prostatica, and a short ductus ejaculatorius. The testes lie at the level of the end of the intestines. They are tandem or slightly oblique, and almost contiguous. They are of very irregular shape, and are always broader than long. Their dimensions are about ·06 × ·13 mm. The post-testicular space is almost exactly one-quarter of the body-length.

The ovary is contiguous with the ventral sucker on its right posterior border. It also touches the right intestinal diverticulum. Its size is ·08 × ·06 mm. The yolk-glands are extremely scattered and imperfectly formed. They consist of small, rather isolated follicles extending along the sides of the body from the middle of the œsophagus to the middle of the post-testicular space. In the latter they extend inwards but do not meet in the middle line. They overlap the intestinal diverticula only to a very slight extent. The uterus is confined between the testes and the ventral sucker, and does not overlap the intestinal diverticula. It contains about two dozen eggs, measuring ·042 × ·021 mm.

It does not appear likely that this can be the young stage of any of the already known species of *Opisthioglyphe*, for it is differentiated from *O. rance* by the length of the intestinal diverticula and the ratio of the suckers. The configuration of the excretory vesicle is also different. From *O. hystrix* it differs in the position of the ventral sucker, the length of the intestinal diverticula and of the cirrus-pouch, and the extent of the yolk-glands. It also differs in several important particulars from the more recently described *O. locellus* Kossack. I am unable to compare it with *O. siredonis*, as Poirier's paper is not available.

5. STYPHLODORA PERSIMILIS, sp. n. (Pl. II. fig. 5.)

About thirty specimens of this parasite were removed from the ureters of an Indian River-Snake (*Tropidonotus piscator*)

which died in the Gardens on December 4th, 1911. Owing to its extreme resemblance to *S. serrata* Lss. and *S. horrida* (Leidy), I have had considerable hesitation in deciding to regard it as a new species. Coming, however, from such different hosts as the Egyptian Monitor (*Varanus niloticus*), *Boa constrictor*, and the present host, and from such widely separated parts of the world as Egypt, North America, and India, the probability is that they represent three distinct species. It also bears some resemblance to *S. najæ* Nicoll (1912) from the Indian Cobra, though the length of the intestinal diverticula and the size of the suckers appear to be characters sufficient to separate it from that species.

The length of mature specimens is 3-4 mm. and the maximum breadth .9-1.0 mm. just behind the ventral sucker. The cuticle is beset with fairly prominent spines throughout practically its whole extent.

The oral sucker measures .24-.28 mm. in diameter and the ventral sucker .28-.34 mm. The latter is almost invariably transversely elongated, its average diameter being $.29 \times .33$ mm. The oral sucker is sometimes elongated, sometimes transverse, the latter being usually the case, and its average dimensions are $.25 \times .26$ mm. The ratio of the mean diameters of the suckers is therefore about 5:6; it is always greater than 4:5 and never greater than 6:7. In *S. najæ* and *S. serrata* the suckers are much more nearly equal. The ventral sucker is situated at a distance of .6-.8 mm. from the anterior end of the body. The neck thus comprises only about one-fifth of the body-length, but it may be remarked that the specimens were somewhat contracted.

There is no prepharynx, and the pharynx measures $.17 \times .13$ mm. The oesophagus is about .1 mm. long, and the intestinal bifurcation takes place close in front of the ventral sucker. The intestinal diverticula are practically equal in length, and extend to a distance of .65-.9 mm. from the posterior end. The average in about a dozen specimens was .76 mm., which is almost exactly two-ninths of the body-length. They are therefore practically about the same length as those in *S. serrata*.

The median genital aperture is immediately in front of the ventral sucker. The cirrus-pouch just reaches the posterior border of the ventral sucker, and is frequently contiguous with the ovary. The latter is globular, with a diameter of .2 mm. Behind it lies the receptaculum seminis. The anterior testis, on the left, lies about .25 mm. from the posterior border of the ventral sucker, though the distance varies from .18 mm. to .38 mm., according to the state of contraction. The posterior testis, on the right, is separated from the other by a distance of .17 mm., though this again varies. The anterior border of the right testis is usually a little in advance of the posterior border of the left.

The yolk-glands have the usual situation, almost entirely

PROC. ZOOL. SOC.—1914, No. X. 10

external to the intestinal diverticula, and extend from the posterior border of the ventral sucker to the middle of the anterior testis. The uterus, which is voluminous, bears a close resemblance to that of *S. serrata*, and the ova measure $\cdot 039\text{--}\cdot 047 \times \cdot 019\text{--}\cdot 020$ mm.

Family DICROCÆLIIDÆ.

6. *LYPEROSOMUM SCITULUM*, sp. n. (Pl. III. fig. 6.)

Four specimens of this species were taken from the liver of a Purple-capped Lory (*Lorius domicella*). It is a greatly elongated form, measuring 6·8–7·2 mm. in length. The breadth is fairly uniform, but attains its maximum (·8 mm.) across the ventral sucker. There are no cuticular spines.

The oral sucker is almost terminal, and has a diameter of ·45 mm.; the ventral sucker is slightly smaller, ·42 mm., and is situated 1·33 mm. from the anterior end. The pharynx is contiguous with the oral sucker, and has a diameter of ·14 mm.; the œsophagus is about the same length. The narrow tortuous intestinal diverticula extend down the sides of the body to a distance of about 2 mm. from the tip of the tail. They are of unequal length, sometimes the right, sometimes the left being the longer.

The anterior testis is separated from the ventral sucker by a space of ·33 mm. The posterior testis lies about the same length behind the first, the latter being close against the right intestinal diverticulum and the former against the left diverticulum. They are oval bodies measuring about $\cdot 25 \times \cdot 33$ mm. The space between the second testis and the ovary is equal to that between the two testes. The ovary is a transversely oval body situated in the middle line and measuring $\cdot 21 \times \cdot 24$ mm. The genital aperture lies over the intestinal bifurcation. The cirrus-pouch is fairly stout, and extends to the anterior border of the ventral sucker. It contains a highly convoluted, voluminous vesicula seminalis and a moderately long prostate and ductus.

The yolk-glands are limited to an area on each side of the body about the level of the ovary. They are variable in extent, but as a rule their anterior limit is on a level with the second testis, while their posterior limit is about half as far again on the other side of the ovary. They are usually more extensive on one side of the body than on the other. They almost completely overlap the intestinal diverticula. The uterus is very highly convoluted, the loops being mostly transverse. It fills up almost all the posterior part of the body not occupied by the genital glands, which it does not overlap. It does, however, overlap the intestinal diverticula to a very considerable extent. The eggs are extremely numerous, and measure $\cdot 029 \times \cdot 019$ mm. The older ones contain the characteristic miracidium larva.

7. *LYPEROSOMUM DIREPTUM*, sp. n. (Pl. III. fig. 7.)

Three fragments of this species were obtained from the liver of a Crested Curassow (*Crax alector*). From these it was possible to get a fairly accurate idea of the whole animal. It is about 9 mm. long and about .9 mm. broad at its broadest part, which is just behind the ventral sucker. The neck narrows rather abruptly, but the posterior part of the body gradually narrows to an acutely pointed tail. At a distance of 1 mm. from the tip of the tail the breadth is less than half what it is behind the ventral sucker. There are no cuticular spines.

The globular oral sucker measures $.35 \times .39$ mm., the ventral sucker $.46 \times .42$ mm., and the latter is 1.03 mm. from the anterior end. In one fragment belonging to a specimen apparently well over 10 mm. in length, the ventral sucker had a diameter of .54 mm. and the maximum breadth of the body was 1.1 mm. The pharynx is contiguous with the oral sucker, and measures $.17 \times .14$ mm. There is practically no oesophagus, the intestinal diverticula branching out directly from the pharynx. The diverticula terminate a considerable distance from the tip of the tail, but the ends are obscured by the uterus, and could not be made out.

The genital aperture lies immediately behind the pharynx. The small slender cirrus-pouch, .3 mm. in length, is slightly curved, and does not reach the ventral sucker. The testes are close behind the ventral sucker, the left being in advance, but only by the distance of its own diameter, so that the posterior border of one is on the same level as the anterior border of the other. They are almost globular, and their diameter varies from .24 mm. to .31 mm.

The globular ovary is separated from the posterior testis by a space of .6 mm. It lies somewhat to the right side, and is rather larger than the testis, having a diameter of .34-.41 mm. Behind it lies a small globular receptaculum seminis. The yolk-glands are much more extensive than in the preceding species. They reach from the level of the posterior testis to halfway between the ovary and the tip of the tail. They are more extensive on one side than on the other. The uterus is very voluminous and highly convoluted, but the convolutions are not quite so regularly disposed as in *L. scitulum*. The very numerous eggs measure $.025-.028 \times .019-.021$ mm.

8. *BRACHYCELUM OBESUM*, sp. n. (Pl. III. fig. 8.)

A few specimens of this species were obtained from the intestine of a Summer Snake (*Contia aestiva*), which died in the Gardens on July 2nd, 1911. They were all, unfortunately, in a very contracted state, and it was only with some difficulty that their internal anatomy could be made out. At first sight they appeared to be identical with *B. salamandre*, but their exceedingly small size and the fact that even the smallest was fully mature, raised

suspicion that this could not be the case. It was difficult, however, to obtain other grounds for regarding them as a distinct species. These relate only to slight differences in the size of the suckers, the cirrus-pouch, and the ova.

The body in its contracted state is plump and equally rounded at both ends. In some specimens each end is curled ventrally. The length of the smallest specimen was .75 mm. and of the largest 1.4 mm., though the latter had been subjected to a certain amount of pressure. In the natural state the length is probably 1-1.5 mm. The greatest breadth, in the middle of the body, is .4-.65 mm. The cuticular spines are rather minute.

The suckers are more unequal than in *B. salamandræ*. The diameter of the oral sucker is .17-.25 mm., the average being .22 mm. The ventral sucker only measures .11-.15 mm., with an average of .135 mm. The ratio is therefore very nearly 5:3 instead of 5:4, as in *B. salamandræ*. The ventral sucker is also nearer the middle of the body, being about two-fifths of the total length from the anterior end.

The pharynx measures .075 × .07 mm.; the œsophagus is short, and the dilated intestinal diverticula reach the level of the middle of the ventral sucker.

The genital aperture has the same position as in *B. salamandræ*, but the cirrus-pouch is much longer and more slender, and it extends right across the ventral sucker to its posterior border. It contains a very large bipartite vesicula seminalis, of which the posterior portion is the larger. The transversely oval ovary lies on the left side immediately behind and overlapping the ventral sucker. Just behind it, and a little external, lies the left testis, while on the other side, on the same level, lies the right testis. The ovary measures .13 × .07 mm.; the testes are somewhat larger. The yolk-glands extend from about the middle of the oral sucker to the level of the ovary. The uterus is very voluminous, and fills up the whole of the posterior part of the body. The arrangement of the convolutions cannot be made out, as they are so closely packed together, but it is noticeable that most of the young eggs are near the tail, while the older eggs occupy a more forward position. The eggs are thick-shelled and somewhat larger than those of *B. salamandræ*, measuring .050-.052 × .034-.036 mm.

This species differs from *B. hospitale* Stafford (1903) in having relatively larger and more unequal suckers. The intestinal diverticula are somewhat longer, and the ova are considerably larger. It is altogether a much smaller species.

Family ECHINOSTOMIDÆ.

9. ECHINOSTOMUM ALIUD, sp. n. (Pl. IV. figs. 9, 9 a.)

Four specimens of this parasite were obtained from the intestine of a Ruddy Flamingo (*Phœnicopterus ruber*). It is an elongated,

somewhat flat species, with a pronounced cervical concavity. As in many other species of the genus, the head has a tendency to be bent sharply on to the ventral surface of the body.

The specimens measured 2.9–6.3 mm. in length. One, 4.6 mm. in length, was immature, but another, of 5.6 mm. in length, was full of ova, so that the maturity length is probably about 5 mm. The greatest breadth, across the ventral sucker, is about one-fifth of the length. Behind the ventral sucker the breadth is fairly uniform, but the tail is distinctly pointed. The breadth across the head is about one-tenth of the body-length.

There are 35 cephalic spines, arranged in the typical fashion in two uninterrupted rows, with a group of five terminal spines at each end. In the anterior row the spines are slightly shorter than in the posterior row, the average size being .099 mm. and .103 mm. respectively. The terminal spines are slightly smaller, measuring .093 mm. The shortest spine on either side is the superficial spine third from the inner end of the terminal group. In the only specimen in which its dimensions could be accurately determined, it measured .091 mm. on the right side and only .078 mm. on the left. The cephalic spines present two peculiarities which have not apparently been observed in any hitherto described species of *Echinostomum*. In the first place their shape is unusual. Instead of the common symmetrical peg-shape, their distal end is inflated in the form of a somewhat triangular knob, which is slightly sculptured. The knob is situated on the upper surface of the spine, and comprises about one-third of its total length. An idea of its shape will best be gathered from reference to fig. 9a. There is the further peculiarity that each spine is connected to the edge of the cephalic disc by a thin web-like membrane which is joined to the spine along pretty nearly its whole length.

The whole of the neck, both dorsally and ventrally, is covered with stout cuticular spines, but these do not extend very far beyond the ventral sucker.

In a 5.6 mm. specimen the large oral sucker measures .22 mm. in diameter, and the ventral sucker .72 mm. The latter is usually globular, but in one case it was somewhat deepened. It lies at a distance of 1.43 mm. from the anterior end. The neck is thus a little more than one-fourth of the body-length. There is a short prepharynx about .06 mm. in length, followed by a pharynx measuring .19 × .13 mm. The oesophagus is about .46 mm. in length, and the bifurcation occurs just in front of the ventral sucker. The diverticula are somewhat crenated, and extend right to the posterior end of the body.

The genital aperture lies in the middle line just over the intestinal bifurcation. The cirrus-pouch is small and stout, and overlaps the ventral sucker only to a slight extent. Its dimensions are .45 × .18 mm., and it encloses a convoluted vesicula seminalis, a short pars prostatica, and a twisted ductus and cirrus. The testes are rather small and of irregular contour, there being

usually a slight indentation on either side about the middle of their length. Their dimensions are $\cdot 34 \times \cdot 25$ mm. The posterior testis is a trifle larger than the anterior one. They are very close together, but are not quite contiguous. In front they are separated from the ovary by a space of $\cdot 15$ mm.; behind them the post-testicular space is $1\cdot68$ mm. in length.

The small transversely oval ovary is situated $1\cdot02$ mm. behind the ventral sucker. It is almost median, and measures $\cdot 15 \times \cdot 21$ mm. The yolk-glands are rather restricted in extent. On each side they reach the posterior border of the ventral sucker; posteriorly they cease at some distance from the tip of the tail. They are for the most part confined to the outer side of the intestinal diverticula, and overlap them only to a very slight extent. The transverse yolk-ducts cross between the ovary and anterior testis. The uterus does not overlap the intestinal diverticula, and is confined between the ovary and the ventral sucker. The ova are very large, measuring $\cdot 114\text{--}\cdot 122 \times \cdot 069\text{--}\cdot 074$ mm.

Family CLINOSTOMIDÆ.

10. HARMOTREMA INFECUNDUM, gen. et sp. n. (Pl. IV. fig. 10.)

A considerable number of specimens of this species was obtained from the intestine of Smyth's Water-Snake (*Grayia smythii*). It is one of the most remarkable forms in the present collection.

It is a small, rather flat species, white in colour and with the edges of the body thrown into irregular wrinkles. The cuticle is unarmed.

It is about 2 mm. in length, with a fairly uniform breadth of $\cdot 6$ mm. Both ends are slightly pointed. The suckers are small and feeble, the oral having a diameter of $\cdot 13$ mm. and the ventral $\cdot 08 \times \cdot 10$ mm. The latter lies $\cdot 8$ mm. from the anterior end.

There is no prepharynx; the pharynx measures $\cdot 06 \times \cdot 04$ mm., and the œsophagus is about the same length as the pharynx. The intestinal diverticula are wide and sinuous, and reach the posterior end of the body. Behind the ventral sucker they usually bend inwards before passing out again to make room for the genital glands. At their termination they again turn in towards the middle line.

The genital aperture is situated on the left side of the body, internal to the intestinal diverticulum and almost midway between the ventral sucker and the posterior end of the body. The curious thin-walled cirrus-pouch stretches forwards from the genital aperture in a zigzag or sinuous fashion, and its proximal end lies against the right intestinal diverticulum. It contains a bipartite vesicula seminalis, of which the proximal part is oval and the distal elongated. There is a moderately

long fusiform pars prostatica and a long curved ductus ejaculatorius.

The testes are two irregularly lobed bodies lying behind the cirrus-pouch. The anterior is just behind the genital aperture but on the right side of the body. The posterior lies between the ends of the intestinal diverticula, and is separated from the end of the body by a space equal to its own diameter.

Between the testes lies the much smaller ovary. It is also irregularly lobed, but not so distinctly as the testes. It is separated from the posterior testes by a large yolk receptacle. The yolk-glands extend a considerable part of the length of the intestinal diverticula and lie both internally and externally to them, but not to any great extent dorsally or ventrally. Their anterior limit is midway between the intestinal bifurcation and the ventral sucker. Posteriorly they cease at the ends of the intestines. The uterus is extremely short and does not usually contain more than two eggs. The latter are comparatively huge but very variable in size. The normal size appears to be about $\cdot 15\text{--}\cdot 18 \times \cdot 08\text{--}\cdot 11$ mm. They lie alongside the ovary and testes.

This species evidently bears a close resemblance to the genus *Harmostomum*, but differs from it particularly in the position of the uterus and the size of the eggs.

HOLOSTOMATA.

11. HEMISTOMUM CANALICULATUM, sp. n. (Pl. IV. fig. 11.)

A few specimens of this parasite were obtained from the intestine of an Egyptian Eagle-Owl (*Bubo ascalaphus*). It is of moderate size, $1\cdot 6\text{--}2\cdot 9$ mm. in length. The anterior part of the body is considerably longer than the posterior part, in the ratio of 5 : 3 on an average. When expanded the anterior part of the body is almost oval in outline, with a pointed tip. The lateral glandular pits are not very well marked. When contracted the body is almost uniformly cylindrical. The long axis of the two parts are almost in the same straight line; so that there is little dorsal flexure. The posterior part of the body may attain a breadth of $\cdot 7$ mm.

The small oral sucker measures $\cdot 08\text{--}\cdot 09$ mm. The ventral sucker is slightly larger ($\cdot 1$ mm.), and is situated at a distance of $\cdot 6$ mm. from the anterior end in a specimen $2\cdot 4$ mm. long. The pharynx is contiguous with the oral sucker and somewhat larger than it, measuring $\cdot 08\text{--}\cdot 1 \times \cdot 06\text{--}\cdot 08$ mm. The short œsophagus measures only $\cdot 03\text{--}\cdot 04$ mm. The diverticula have the usual configuration.

The most characteristic feature of the species is the clinging-plug, which is situated immediately behind the ventral sucker. It is an oval structure about four times as long as the ventral sucker and two or three times as broad. It does not conceal

the ventral sucker, but in the older specimens it overlaps the posterior border of the sucker. It is not much raised above the surface of the body, and is traversed by a deep median longitudinal furrow which extends along its whole length. In well-expanded specimens the furrow is much shallower. A similar furrow exists in *H. pileatum* (Rud.).

The genital glands do not display any striking peculiarities, except that the testes are reniform in transverse section and the yolk-glands extend forward only to about .5 mm. from the anterior end. Their anterior edge forms a semi-circle with the convexity directed forward.

The ova measure .105-.11 × .065-.07 mm.

This species bears most resemblance to *H. spathula* (Creplin), but differs from it in several important details. In the latter the two parts of the body are nearly equal; the oral sucker and the pharynx are only half as large, while the clinging-plug is much larger and does not display the longitudinal furrow. The yolk-glands, too, are probably more extensive.

The following is a list of the hosts and of the Trematode parasites obtained from them:—

MAMMALS.

ANOA DEPRESSICORNIS.

Fasciola gigantea (Cobbold) Liver.

BIRDS.

CIRCUS ÆRUGINOSUS. Marsh Harrier.

Metorchis crassiusculus (Rud.) Liver and Gall-bladder.

BUBO ASCALAPHUS. Egyptian Eagle-Owl.

Hemistomum canaliculatum Nicoll Intestine.

LARUS RIDIBUNDUS. Black-headed Gull.

Gigantobilharzia acotylea Odhner Mesenteric veins.

LARUS FUSCUS. Black-backed Gull.

Tocotrema lingua (Creplin) Intestine.

LARUS ATRICILLA. Laughing Gull.

Tocotrema lingua (Creplin) Intestine.

ALCA TORDA. Razorbill.

Hemistomum pileatum (Rud.) Intestine.

Metorchis xanthosomus (Creplin) Gall-bladder.

CEDEMIA NIGRA. Black Scoter.

Catatropis verrucosa (Froelich) Cæca.

Paramonostomum alveatum (Mehlis) Intestine.

LORIUS DOMICELLA. Purple-capped Lory.

Lyperosomum scitulum Nicoll Liver.

PHENICOPTERUS RUBER. Ruddy Flamingo

Echinostomum aliud Nicoll Intestine.

CRAX ALECTOR. Crested Curassow.

Lyperosomum direptum Nicoll Liver.

REPTILES.

TROPIDONOTUS ORDINATUS. Striped Snake.	
<i>Cercaria ordinata</i> Nicoll	Mesentery.
<i>Diplostomum sirtale</i> Nicoll	Mesentery.
<i>Mediorima propria</i> Nicoll	Intestine.
TROPIDONOTUS PISCATOR. Indian River-Snake.	
<i>Styphlodora persimilis</i> Nicoll	Ureters.
TROPIDONOTUS NATRIX. Common Snake.	
<i>Cercorchis nematoides</i> (Muhling)	Intestine.
NAJA TRIPUDIANS. Indian Cobra.	
<i>Xenopharynx solus</i> Nicoll	Gall-bladder.
<i>Styphlodora najæ</i> Nicoll	Ureters.
PHILODRYAS SCHOTTI. Schott's Snake.	
<i>Opisthogenes interrogativus</i> Nicoll	Intestine.
GRAYIA SMYTHII. Smyth's Water-Snake.	
<i>Harmotrema infecundum</i> Nicoll	Intestine.
VIPERA ASPIS. Asp Viper.	
<i>Opisthioglyphe adulescens</i> Nicoll	Intestine.
<i>Cercaria ordinata</i> Nicoll	Mesentery.
CONTIA ÆSTIVA. Summer Snake.	
<i>Brachycælium obesum</i> Nicoll	Intestine.
UROMASTIX ACANTHINURUS. Spiny-tailed Mastigure.	
<i>Ommatobrephus singularis</i> Nicoll	Intestine.

References.

1. KOSSACK, W. 1910.—Neue Distomen. Centralbl. für Bakteriologie, &c., 1 Abt. Orig. lvi. pp. 114–120.
2. LEIPER, R. T. 1911.—(Demonstration of Nematode Parasites). Proc. Zool. Soc. 1911, pp. 620–621.
3. NICOLL, W. 1911.—On three new Trematodes from Reptiles. Proc. Zool. Soc. 1911, pp. 677–686.
4. NICOLL, W. 1912 a.—On two new larval Trematodes from the Striped Snake (*Tropidonotus ordinatus sirtalis*). Proc. Zool. Soc. 1912, pp. 767–770.
5. NICOLL, W. 1912 b.—On two new Trematode parasites from the Indian Cobra. Proc. Zool. Soc. 1912, pp. 851–856.
6. STAFFORD, J. 1903.—Two Distomes from Canadian Urodela. Centralbl. f. Bakt., &c., 1 Abt. xxxiv. pp. 822–830.
7. WEST, G. S. 1896.—On a new species of *Distomum*. Journ. Linn. Soc. Lond., Zool. xxv. pp. 322–324.

EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1. *Mediorima propria*. × 20.
 2. *Ommatobrephus singularis*. × 40.
 3. *Opisthioglyphe adulescens*. × 70.

PLATE II.

- Fig. 4. *Opisthogenes interrogativus*. $\times 25$.
 5. *Styphlodora persimilis*. $\times 40$.

PLATE III.

- Fig. 6. *Lyperosomum scitulum*. $\times 23$.
 7. *Lyperosomum direptum*. $\times 18$.
 8. *Brachycœlium obesum*. $\times 100$.

PLATE IV.

- Fig. 9. *Echinostomum aliud*. $\times 20$.
 9a. " " Cephalic spine. $\times 250$.
 10. *Harmotrema infecundum*. $\times 60$.
 11. *Hemistomum canaliculatum*. Transverse section through
 clinging-plug. $\times 65$.

Figures 1-10 are drawn from the ventral surface.

C.B. Cirrus-pouch.
Ex. Excretory vesicle.

K.St. Ovary.
T., T₁, T₂. Testes.

10. On the Skull of a Pariasaurian Reptile, and on the Relationship of that Type. By D. M. S. WATSON, M.Sc., F.Z.S., Lecturer on Vertebrate Palæontology in University College, London.

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(Text-figures 1-7.)

INDEX.	Page
Statement of material used	156
Description of the Skull	156
Brain-case	156
Palate	160
Roof	162
Relations of bones of cranial roof	163
The Skull of <i>Anthodon</i>	165
Discussion of the Skull	166
The Sphenethmoid in early Tetrapods	166
The Squamosal	169
Systematic position and Relationship of <i>Pariasaurus</i>	170
Diagnostic characters of the Cotylosauria	170
Comparison of <i>Pariasaurus</i> with other Cotylosaurs	172
General characters of Deinocephalia	175
" " Anomodontia	176
" " "Therocephalia" and "Cynodontia"	176
" " Dromasauria	177
Diagnostic characters of the Therapsida	178
Comparison with the Pelycosauria	178
Comparison of <i>Pariasaurus</i> with the Therapsids	179
Acknowledgements	180

In 1838 Andrew Geddes Bain discovered, on the Blinkwater Commonage, in Cape Colony, the skull and a good deal of the skeleton of a large reptile, which was subsequently described by Owen as *Pariasaurus serridens*. Our knowledge of the structure of the animal remained very slight until H. G. Seeley, in 1888, described a skull and axial skeleton referred to *Pariasaurus bombidens* *. Some years later he obtained in South Africa a fine skeleton, and the imperfect skull and axial skeleton of another, of which he gave a good description.

In 1893 E. T. Newton gave an excellent account of the skull of *Elginia mirabilis*, a closely allied reptile from the Upper Permian Culties Hillock Sandstone of Elgin.

A. S. Woodward, in 1898, published a diagram of the palate of *Pariasaurus*, which he correctly interpreted. Broom, in several papers, has added to our knowledge of *Pariasaurus* and allied types; and J. Versluys has corrected his account of the palate.

* It is almost certain that *P. bombidens* is not congeneric with *P. serridens*. As this paper is purely morphological I have postponed all discussion of nomenclatorial difficulties to a more fitting occasion.

Despite this large amount of work, practically nothing is known of the detailed structure of the skull, and I was therefore very pleased to find that a fossil I collected on the farm Hottentots Rivier, Gouph, Beaufort West, Cape Colony, would enable me to give a nearly complete description of the skull. With this description *Pariasaurus* becomes, on the whole, the best known Permian vertebrate.

The material I have used consists of:—

I. A skull from Hottentots Rivier. This apparently belongs to the same species as the skeleton in the South African Museum described by Broom as *P. serridens*, a species to which it certainly does not belong. It differs from *P. bairdi* in many features of the skull and skeleton, and is probably quite worthy of generic rank.

This specimen consists of the entire brain-case, which has been very completely cleaned inside and out, the posterior part being divided by a sagittal cut, and the anterior part sliced through horizontally. The whole of the right side of the skull-roof is very perfectly preserved, and the fragment extends so far across the middle line as to give the shape of the skull and the complete structure with certainty. The sutures are shown only on the inner surface. The palate is missing.

II. No. 49426, British Museum (Natural History), is the skull of the specimen collected by T. Bain at Palmiet Fontein, Dist. Beaufort West, described by Seeley as *P. bombidens*. His lithographic figures give a good idea of the specimen, which, however, has been very much more developed, the palate having been completely freed from the stone on both palatal and dorsal surfaces and the lower jaw disarticulated.

Many, but not all, Prof. Seeley's sutures are correctly determined, and it is certain that the structure is essentially similar to that of specimen I.

III. R. 1970 is the Tamboer Fontein specimen of *P. bombidens* collected by Prof. Seeley; it shows the entire structure of the palate well-preserved and perfectly prepared, the sutures being visible on the dorsal surface.

DESCRIPTION OF SKULL, *drawn mainly from the Hottentots
Rivier specimen; others are indicated when used.*

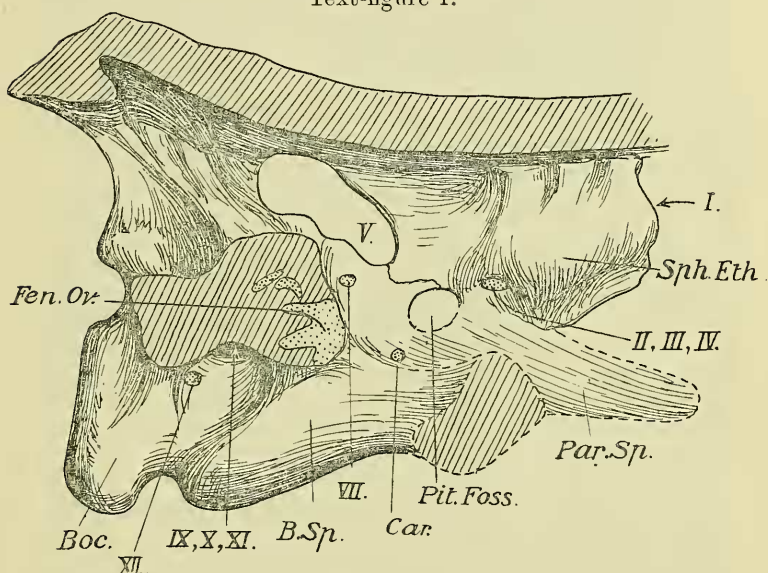
The bones of the brain-case are fused into a single mass of bone in which sutures are not distinguishable. The various regions are, however, readily identified, and are used in the following account.

Basioccipital.—The basioccipital is a large bone whose posterior end forms the condyle. This is almost exactly circular, but its border is slightly depressed below the foramen magnum. The outer part of the condyle is rounded, but the centre is depressed into a deep conical notochordal pit exactly similar to that which occurs in every vertebral centrum of the animal. The condyle is separated off from the body of the bone by a neck formed by a

groove running round the bone, which particularly impresses the lower surface. In section a disturbance of the cancellar tissue suggests the point of separation of the basisphenoid. The upper surface of the basioccipital supports the very massive exoccipital, in front of which its upper surface is excavated on each side of the middle line by a deep pit, continued outwards by a groove which forms the lower half of the enormous foramen jugulare.

The lower part of the basioccipital is almost entirely concealed by the overlapping basisphenoid, but it is produced in low yet massive tubera basisphenoidales.

Text-figure 1.



The cranium of "*Pariasaurus*," the Hottentots Rivier specimen, viewed from the side. ($\times \frac{1}{3}$).

Boc., Basioccipital; *B.Sp.*, Basisphenoid; *Car.*, Canal for internal carotid artery; *Fen.Ov.*, Fenestra ovalis; *Par.Sp.*, Parasphenoid; *Pin.*, Pineal foramen; *Pit.Foss.*, Pituitary fossa; *Sph.Eth.*, Sphenethmoid. The figures I-XII refer to the exits of the cranial nerves.

Basisphenoid.—The basisphenoid covers the lower surface of the anterior part of the basioccipital, sending back processes over those of the basioccipital to form the tubera. They are continued forward as strong rounded ridges on each side of the bone which pass into the great basiptyergoid processes, very well shown on R. 1870. These project downwards and outwards, leaving between them a deep channel on the under surface of the bone. They are of irregular shape, and the pterygoids articulate with a

very large area of the outer surface. In advance of them a narrow rostrum, which is probably to some extent parasphenoid, projects forward and articulates with a special facet on the dorsal surface of the pterygoids so as to divide completely the interpterygoid vacuity.

Although the lower surface of the basisphenoid is very long its upper surface is short, owing to the great anterior production of the basioccipital. The lateral border of the upper surface and a good deal of the side of this bone are covered by the prootic. In advance of this region the bone suddenly narrows, its sides being in contact with the sphenethmoid. The front of the bone terminates in a smoothly rounded edge, which is the back of the opening to the pituitary fossa. This runs backwards with sides widely open above the basipterygoid processes; its base is closed by the upper surface of the rostrum, and in front it passes into the cavity of the sphenethmoid. The internal carotids enter the pituitary fossa by a single foramen, which leads into a canal passing down in the body of the basisphenoid for about a centimetre and then splitting into two, which pass out on the sides of the bone above the basipterygoid processes. In front of the pituitary fossa the rostrum is in contact with the under surface of the sphenethmoid.

Otic bones.—The side walls and roof of the posterior part of the brain-case are formed by the fused otic bones and exoccipitals. The exoccipital part of the mass forms a massive pillar pierced near its base by a single small foramen for the XIIth nerve; its anterior border forms the back of the huge jugular foramen, which is about 1.5 cm. in diameter; it must form part of the very powerful paroccipital process, and it is not improbable that the two exoccipitals met above the foramen magnum.

The front border of the jugular foramen must be formed by the opisthotic, which is so fused with the prootic and supraoccipital that it is hopeless to separate them; the three bones with the exoccipital form a very massive paroccipital process, whose outer end is firmly united with the tabular and squamosal by an irregular suture seen only in fractures.

The foramen jugulare issues below and behind the process, and on its lower front surface, not very far out, is the fenestra ovale, a large hole of irregular shape.

In section, on the left side, the horizontal semicircular canal and part of the vestibule are seen filled with matrix.

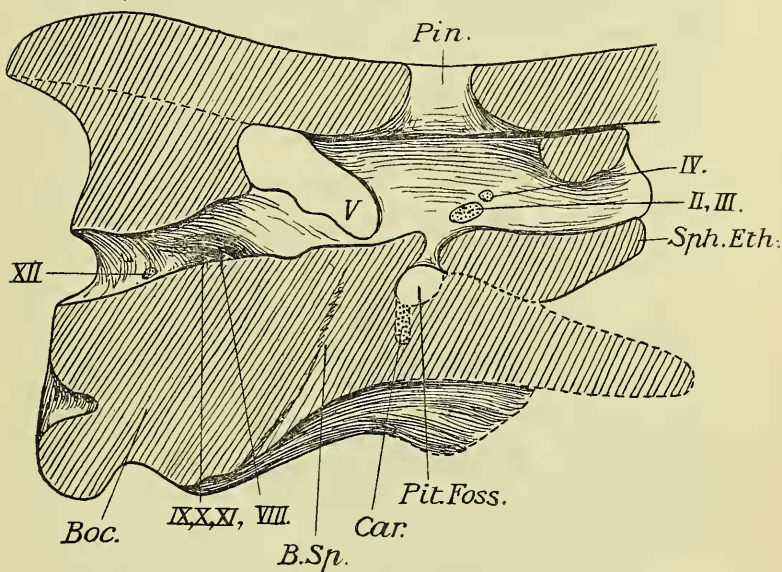
The foramen through which the VIIIth nerve gains entrance to the ear lies far out on the front wall of the bony canal, which forms the foramen jugulare. The foramen is a small one, the vestibule being separated from the brain-cavity by bone and not merely a membrane, as in most early reptiles.

The aqueductus fallopii for the VIIth nerve has an exit on the outer surface of the prootic in advance of and slightly above the fenestra ovale; its opening to the brain-cavity is not quite certain.

The front border of the prootic forms a smooth curve with a notch at the bottom for the exit of the Vth and VIth nerves.

The supraoccipital part of the brain-case is produced upward as a very massive process of roughly quadrangular section channelled and grooved vertically and fused with the postparietals over a large area. This separates the large posttemporal fossæ.

Text-figure 2.



The cranium of "*Pariasaurus*," the Hottentots Rivier specimen, in sagittal section, $\times \frac{1}{2}$.

Reference-letters as before.

The *Sphenethmoid*.—The anterior part of the brain is surrounded by a single bone, which I can only compare with the sphenethmoid of a frog.

Posteriorly, on either side of the pineal foramen, this bone forms a flat thin plate which thickens and turns inwards as it passes downwards until it unites with the side of the basisphenoid above the pituitary fossa. In this region the brain-cavity is roofed solely by the parietals, but farther forward the cavity of the sphenethmoid contracts very much, and the bone becomes quite continuous over the brain: in this region the bone is massive although of very loose texture. Farther forward the cavity suddenly widens.

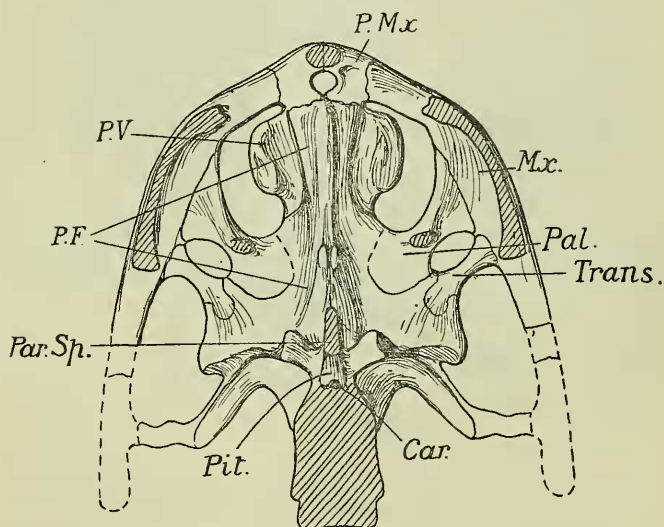
The thick floor is directly continuous with the parasphenoidal rostrum, from which it is not visibly separated by suture (49426).

The bone is apparently all one, there being no visible sutures, and it is very clearly distinct from the membrane bones of the skull roof.

Viewed from within its floor is pierced by two pairs of foramina: the posterior are large rounded openings, for the IInd and IIIrd nerves; the anterior are much smaller foramina lying somewhat outside the others, and possibly transmitted the IVth cranial nerves. These two foramina have a common opening on the outside.

The olfactory nerves passed out by the widely open front of the bone.

Text-figure 3.



The palate of *Pariasaurus bombidens*, $\times \frac{1}{2}$.

Viewed from above, the top of the skull being cut off about 5 cm. above its dorsal surface.

Reference-letters as before, with:—*Mx.*, Maxilla; *Pal.*, Palatine; *P.V.*, Prevomer; *P.F.*, Pterygoid; *Trans.*, Transpalatine.

The *Palate*.—The general form of the palate has long been known, and the distribution of the teeth with which it is armed was fully described by Seeley (1892).

R. 1870, which shows the sutures between the bones on the dorsal surface, 49426, which illustrates very well its general form and relation, and another specimen, collected by myself at Hottentots Rivier, enable me to complete our knowledge.

Pterygoid.—The pterygoid is a large triradiate bone. It articulates by an immovable and very powerful junction with the basiptyergoid process of the basisphenoid.

The anterior ramus runs forward at a lower level than the basipterygoid process, in contact with its fellow, nearly to the extreme front of the skull, where the bone ends in an overlap on the palatal process of the premaxilla. The two taken together form a powerful ridge along the dorsal surface of the palate, which is particularly high in the region of the prevomers, and further back is thickened to articulate with the anterior end of the parasphenoidal rostrum.

The front part of the pterygoid is underlain by the prevomer, as is well seen in a section of the second Hottentots Rivier specimen.

The lateral border of the anterior ramus is in contact with the palatine, and the external ramus supports the ectopterygoid and with it forms the small pterygoid flange which faces the inner side of the lower jaw.

The posterior ramus runs outwards and backwards from the basipterygoid process; it forms a deep plate very thick and solid below, nearly the whole of whose anterior face is covered by the quadrate. This flange reaches nearly to the roof of the skull, and at its upper edge apparently touches, in 49426, a special process of the squamosal which will be described later.

Epipterygoid.—No. 49426 on the right side shows appearances suggesting the presence of a small epipterygoid resting on the upper surface of the pterygoid. I have seen a similar suggestion in another specimen, but am not prepared definitely to affirm the presence of the bone.

Prevomer.—The prevomer is a large thick bone which meets its fellow in the middle line, whose dorsal surface is partly covered by the pterygoid and whose lower surface supports two irregular rows of teeth: these are quite large, recurved, and sharply pointed; in section they are seen to be set in distinct sockets.

Palatine.—The extension of the palatine on the buccal surface of the palate cannot be determined. An interesting feature of its dorsal surface is the presence of a process which is directed upwards and articulates with a corresponding descending process of the prefrontal. The outer edge of the palatine articulates wholly with the maxilla.

Ectopterygoid.—An ectopterygoid is undoubtedly present. It unites with the external ramus of the pterygoid and passes outwards behind the suborbital vacuity to articulate with the maxilla, lachrymal, and jugal.

A very curious feature of the palate is the presence of a large round opening between the palatal processes of the premaxille, which probably housed an intermaxillary gland.

Quadrate.—The quadrate is a large bone standing nearly vertical in the skull. Its lower border forms the condyle for the lower jaw, which is placed nearly transversely.

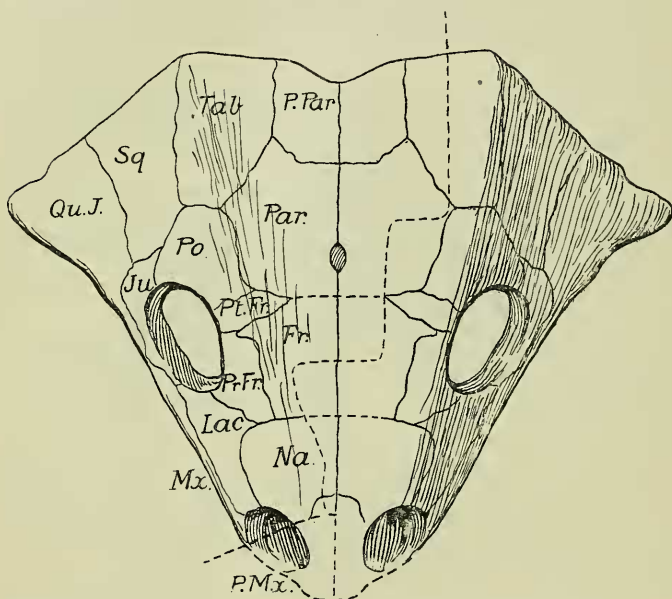
The bone rises above this as a plate whose outer border is notched at one place by the very small quadrate foramen, but is

otherwise in contact with the quadratojugal and squamosal throughout its whole height.

The body of the bone passes gradually into a powerful pterygoid ramus, which covers nearly the whole of the posterior ramus of the pterygoid.

The upper border of the bone is covered by a special process of the squamosal.

Text-figure 4.



The skull of "*Pariasaurus*," Hottentots Rivier specimen, $\times \frac{1}{6}$. Dorsal aspect.

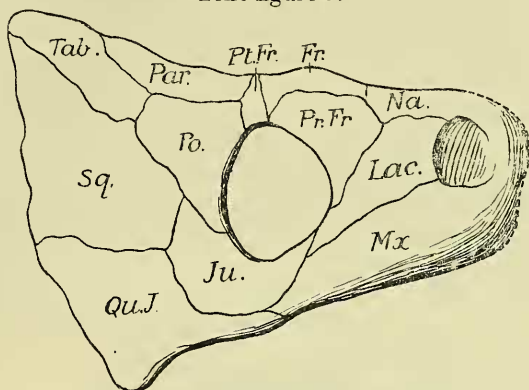
The sutures have only been seen on the inner surface and are drawn here on the assumption (apparently justified by the specimen) that they pass through at right angles to the surface. The part to the left of the thick dotted line is not preserved in the specimen.

Fr., Frontal; *Ju.*, Jugal; *Lac.*, Lachrymal; *Mx.*, Maxilla; *Na.*, Nasal; *P.Par.*, Postparietal; *Po.*, Postorbital; *Pt.Fr.*, Postfrontal; *Pr.Fr.*, Prefrontal; *Par.*, Parietal; *Qu.*, Quadrate; *Qu.J.*, Quadratojugal; *Sq.*, Squamosal; *Tab.*, Tabulare.

Roof of the Skull.—The general structure of the roof of the skull will be more readily understood from text-figs. 4 and 5 than from any description. It must, however, be remembered that all the sutures shown in these figures have been seen only on the inside of the skull, their positions on the outside being drawn on the assumption that the sutures pass straight through at right angles to the surface; observations on fractures show that this is really the case. It is impossible to give an intelligible figure of

the inside of the skull, and no errors of any morphological importance can possibly be introduced by the method of figuring I have employed here.

Text-figure 5.



The skull of "*Pariasaurus*," Hottentots Rivier specimen, $\times \frac{1}{6}$. Side view.

Reference-letters as before.

The most striking features of the skull pattern are :—

1. The very large size of the parietals, frontals, and nasals.
2. The very reduced postfrontal wedged in between the frontal, prefrontal, parietal, and postorbital.
3. The very great downward extension of the prefrontal, so that it nearly reaches the jugal.
4. The fact that, as is usually the case in primitive reptiles, the lacrymal enters into both the nostril and the orbit.
5. The shallowness of the maxilla.
6. The fact that the quadratojugal meets the maxilla.
7. The large size of the postparietal and tabulare, which are placed immediately behind and in the same plane as the parietal and postorbital.
8. The reduction of the bones in the temporal region to one on each side.

*Description of the Attachment of Bones of the Cranial Roof
to Underlying Bones.*

Postparietal.—The two postparietals fuse in the middle line, no suture being visible. Their posterior edge projects freely at the back of the skull, and the top of the supraoccipital is tightly fused on to their lower surface near the front.

Parietal.—The parietals completely surround the pineal foramen, which is of moderate size. Near their posterior border they are in contact with the supraoccipital, and further forward with the sphenethmoid.

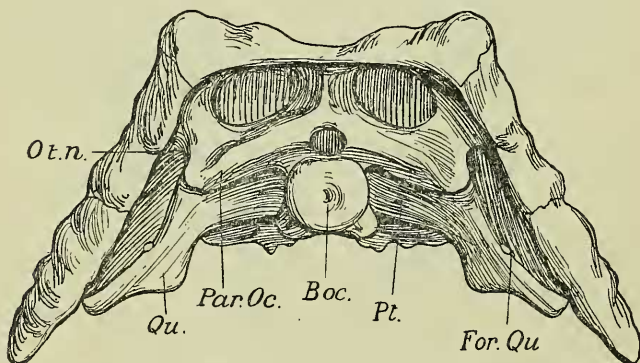
Frontal.—The frontals are in contact with the anterior part of the sphenethmoid.

Tabulare.—The tabulare is a large bone which has a large and very firm attachment to the end of the paroccipital process.

Squamosal.—The squamosal is a large bone on the side of the skull which has an articulation with the outer edge of the quadrate, and in addition sends a special delicate process back over the top of that bone. In the Hottentots Rivier specimen these two bones are not quite in contact, but in 49426 they are for a long distance, and it is very probable that the end of the squamosal process is in contact with the pterygoid.

The squamosal is produced into a plate on the outer surface of the skull behind the quadrate, and on the border of this, just below the paroccipital process, is a small smooth groove, the last remnant of the otic notch.

Text-figure 6.



The skull of "*Pariasaurus*," Hottentots Rivier specimen, restored, from behind.

Reference-letters as before, with *Ot.n.*, otic notch.

Quadratojugal.—The quadratojugal is a very large bone which has an articulation with the outer side of the quadrate, and helps to form the minute foramen quadrati. It is, however, largely produced behind and below this bone.

Maxilla.—The maxilla is a shallow bone, articulating along the whole of its upper edge with the lachrymal and posteriorly with the jugal and quadratojugal. It is almost certain that it really overlaps the lachrymal so as to be rather higher than it is represented in text-fig. 5.

It bears numerous teeth, which are inserted in sockets and very firmly held by the development of bone round their roots. On the inner side the maxilla articulates with the ectopterygoid and the palatine.

Prefrontal.—The large prefrontal sends a process downwards

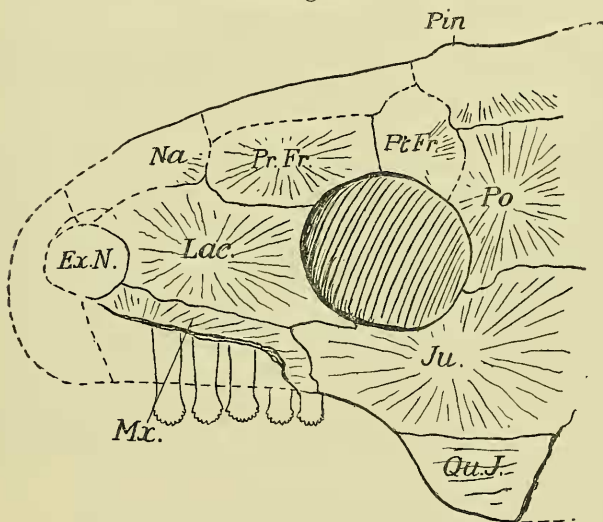
within the lachrymal just in front of the orbit, which reaches and articulates with the corresponding process on the upper surface of the palatine.

Septomaxillare.—Despite the fact that this bone has been described by Seeley and Broom, I can find no certain evidence of its presence, and believe that if it existed, as it probably did, it was only loosely placed in the nostril as in *Sphenodon* and most *Stegocephalia*.

Stapes.—A small fragment of bone lying in contact with the fenestra ovale on the right side of the Hottentots Rivier specimen, is probably the proximal end of a stapes; it is very imperfectly preserved, but seems to be a plain plug about 10 mm. across proximally, rapidly narrowing to 6 mm.

The only other types of Pariasaurian skull that are at my disposal are: 1st, the type skull of Owen's *Anthodon serratus*, and 2nd, the type skull of *Elginia mirabilis*.

Text-figure 7.



The type-skull of *Anthodon serratus* Owen, $\times \frac{1}{2}$.

The side of the face, showing the sutures.

This sketch should be compared with Owen's excellent lithographic drawing.

The skull of *Anthodon* is very badly preserved, being crushed, weathered, and all the surface removed from what bone remains; none the less it shows the sutures between the bones of the side of the skull quite clearly, they being indicated by the direction of the radiating fibres of the bones.

The structure will be most clearly understood from text-fig. 7.

The general plan of the structure is the same as in the larger and older South African *Pariasaurs*, but the more remarkable specializations of the latter types are absent; for example, the quadratojugal, though it does extend forwards below the jugal, does not reach the maxilla, and the lacrymal has a large exposure in the orbital margins. The quadrate is present in the specimen at the extreme hinder end of the part preserved.

General Discussion of the Skull.

Basis Cranii.—The occipital condyle is rather unusual in the great development of the pit for the anterior end of the notochord, which renders it on the whole concave; a similar condition occurs in *Diadectes* and *Limnoscelis* amongst early reptiles, and in a still more marked form amongst the primitive amphibia *Loxomma*, *Pteroplax*, etc. The condition is a primitive one.

The basisphenoid, except for its very great mass, agrees in its structure with that of most *Cotylosaurs*, having very powerful tubera and distinct basiptyergoid processes.

The parasphenoid, which is as usual indistinguishably fused with the basisphenoid, is of great length and touches the pterygoid in front as in *Labidosaurus*, *Seymouria*, and many other *Cotylosaurs*.

Brain-case.—The more remarkable features of the posterior part of the brain-cavity depend very largely on the fact that *Pariasaurus* is a large and very massively built animal. The great development of the supraoccipital region and its powerful fusion with the roof of the skull, so different from the conditions in such types as *Procolophon* and *Labidosaurus*, are probably produced in response to a mechanical necessity. The long, low, and wide form of the brain-cavity is a very remarkable feature which is not, so far as I know, paralleled by any other reptile.

The determination of the nerve-exits presents no difficulty, and the only unusual feature, the entrance of the VIIIth nerve into the ear on the anterior wall of the bony canal which forms the foramen jugulare, is, I believe, very largely dependent on the enormous size of the latter.

The ear, so far as can be seen, is of a very ordinary description, lying well up in the side wall of the brain-case.

It is apparently certain that the VIth nerve did not pierce the basisphenoid but must have issued through the prootic fissure.

Sphenethmoid.—The sphenethmoid was the name given by W. K. Parker to the small ring-shaped bone which surrounds the anterior part of the brain in the frog (Cuvier's *os en ceinture*).

In the frog it is a ring-shaped bone, ossified in the cartilage of the anterior part of the brain-case, and lying between the membrane-bones of the roof of the skull and those of the palate, particularly the parasphenoid, which it directly overlies. The whole bone in this animal lies in advance of the points of exit

of the optic nerves, but the olfactory nerves pass out in front of it.

A bone exactly corresponding to this in all its relations occurs in many Stegocephalia; it has been figured as a "Rhinencephalic chamber" by Williston in *Cacops* and *Aspidosaurus novomexicanus*, the latter specimen giving evidence from the fact that it is displaced, that it is not a downgrowth of the bones of the skull roof. By Fraas it has been figured but not determined or described in *Cyclotosaurus posthumus*, and it also occurs in some specimens of "*Bothriceps*" *huxleyi*.*

It is, however, much best shown in a skull in the Pretoria Museum found at Senekal, O. F. S., which is one of the specimens described by v. Hoepen as *Myriodon senekalensis*. In that specimen the roofing bones have been split away leaving the impression of their lower surface on the matrix, through an extremely thin and transparent film of which the upper surface of the sphenethmoid is clearly seen to be quite continuous over the brain. None of these specimens shows the distinction of the bone from the parasphenoid of which it might conceivably be an outgrowth; but a large and well-preserved skull apparently of a form very near to *Capitosaurus*, which I found on the farm Watford, Dist. Albert, Cape Colony, in the Cynognathus beds, shows the bone clearly, and it is extremely spongy, quite different from the hard membrane-bone of the parasphenoid.

No. 36358 in the British Museum is a fragment of a skull of *Capitosaurus nasutus*, Meyer, from Bernberg. It shows the right side of the face with the orbit, and on the back of the specimen part of the vertical plate of pterygoid which passes backward to the quadrate. In advance of this lies the sphenethmoid, only the right wall of which is preserved, and that with its inner surface destroyed so that the loose cancellar tissue is visible. The posterior end of the bone has a notch which presumably transmitted the optic nerve, and the anterior end is also notched. This bone is extremely clearly shown to rest in the deeply grooved upper surface of the parasphenoid.

This specimen affords conclusive evidence that the "rhinencephalic chamber" is a separate bone, for there can be no doubt of the interpretation of the present fragment, as the bone from its structure is obviously not the prootic, and also lies far in advance of the actual position of that bone in all known Stegocephalia. It is therefore certain that a bone surrounding the anterior part of the brain and separating the exits of the olfactory and optic nerves, which lies freely between the parasphenoid and the membrane-bones of the roof of the skull, occurs in many Temnospondylous and Stereospondylous Stegocephalia, and as it agrees exactly in all features with the sphenethmoid of the frog should be called by that name.

The bone which has been described above as surrounding the

* Since this was written Broom has described the sphenethmoid in *Eryops*.

anterior part of the brain in *Pariasaurus* differs from the sphenethmoid only in that its lateral walls are produced backwards so as to surround the exit of the optic nerve and reach the basi-sphenoid. In my opinion such a change, depending in the end solely on the degree to which ossification has proceeded, is not an important one, and we are thus justified in calling the bone in *Pariasaurus* also a sphenethmoid.

In the large Coal-measure amphibia such as *Pteroplax*, which I hold to be (in the wide sense) ancestral to both the Rachitomous and Stereospondylous Stegocephalia and the Cotylosauria, there is a great mass of bone, sheathing the front of the brain and passing forward as a septum nearly to the front of the head. From such a bone the sphenethmoid of *Pariasaurus*, like that of the later Stegocephalia, is easily derived by reduction. If this view be true, it will follow that W. K. Parker was essentially justified in identifying the pair of bones in the brain-case of Urodeles usually called "orbito-sphenoids" with the frog's sphenethmoid, for they also can be readily derived from the *Pteroplax* ethmoidal complex.

The bone is also interesting from the light it throws on the ethmoid of Therapsids. This bone has been carefully and excellently described by Prof. and Miss Sollas in *Dicynodon* and I know it well in *Endothiodon*, where it has an essentially similar structure. In this type it consists of a short, thick median septum which rests on the dorsal surface of the "vomer," which in Anomodonts is certainly composed of a pair of fused prevomers. This septum at the top and the back is split into two branches which form a covering to the olfactory nerves, which issue at the sides of the bone at about half its length, and are in front separated from one another by the septum reaching up to the roof of the skull. This bone is even more like the sphenethmoid of the frog than is that of *Pariasaurus*. There can be no doubt that it is homologous with the bone I described and called ethmoid in the skull of a Gorgonopsid.

Nor can there be any doubt in my opinion that the "mesethmoid" described in *Diademodon* by Dr. Broom and myself really represents the lower septal part of this bone, for it lies on the dorsal surface of the palate, above the vomer in some species and altogether in advance of it in the region of the palatines in others.

There can, I think, from a study of some models of a foetal skull of *Perameles* which Mr. R. W. Palmer was good enough to show me, be no doubt that this bone is correctly interpreted as the mammalian mesethmoid.

If this series of comparisons be justified, we shall have shown that the mesethmoid of a mammal, the ethmoid of Anomodonts, Gorgonopsids, and Cynognathids, the sphenethmoid of Batrachia, and the orbitosphenoids of Urodeles are all allied bones, and that they have all been derived from a condition resembling that

found in *Pariasaurus*, and in a more primitive form in *Pteroplax* and other Embolomorous Stegocephalia.

It may at some future time be possible to bring this bone into relation with the so-called alisphenoids of Crocodiles, which, as is already generally recognized, have nothing to do with the mammalian alisphenoid, but in the present state of our knowledge of the development of the crocodile skull it is unwise to institute such a comparison.

With regard to the identification of the nerve-exits little can be said. The large foramen is undoubtedly for the optic nerve, and the small foramen above it can only be for the trochlearius, its peculiar position being somewhat paralleled by a metamorphosing skull of *Rana temporaria* figured by Gaupp, fig. 372, Band iii. Hefte 2, of Hertwig's 'Handbuch der Entwicklungslehre.'

Palate.—The palate of *Pariasaurus* only differs from the primitive reptilian condition in the fact that the pterygoids extend forwards over the prevomers to reach the premaxillæ. I believe this unusual character to be an adaptive one. The whole palate of *Pariasaurus* is covered with a unique armature of small, sharply pointed teeth. The whole structure is such as to give very great strength to the roof of the mouth. The bone is thick, the middle line is raised into a ridge which forms a girder along the dorsal surface; in the prevomerine region this may be six centimetres deep; posteriorly the pterygoids are supported by the anterior end of the parasphenoid which, with the massive sphenethmoid above it, form a rigid connection between the palate and the roof of the skull. Finally, the palatine is supported about the middle of its area by the descending process of the prefrontal. The whole forms an assemblage of supports scarcely paralleled in any other type.

Squamosal.—The presence of only one bone in the temporal region makes it necessary to discuss which of the three bones of a primitive reptile has survived in *Pariasaurus*.

The relations of the quadrate in all Embolomorous, Rachitomous, and Stereospondylous Stegocephalia are in essentials identical, although they have seldom been accurately described, probably because they are usually best shown in broken and unpromising looking fragments. In all types of which I have been able to examine satisfactory material [*Pteroplax*, "*Loxomma*," "*Bothriceps*," *Micropholis*, *Capitosaurus*, *Trematosaurus*, *Batrachosuchus*, *Aphaneramma*, and others] the quadrate is a bone consisting essentially of a thick lower margin, provided with condyles for the articulation of the lower jaw, from which runs a thin plate which inclines more or less forwards. The posterior surface of this plate is covered to a greater or less degree by the posterior ramus of the pterygoid, which in later types is connected with a thin vertical wall rising nearly to the roof of the skull, and by the posterior edge of the outer and lower of the

temporal bones, the squamosal. In the majority of types the pterygoid and squamosal meet behind the quadrate, often in a long suture.

The other two bones never in my experience have any relation with either the quadrate or the pterygoid.

Dr. Broili's figures and descriptions of the type skulls of *Seymouria bayloriensis* show that that remarkable reptile is identical in the structure of the temporal region and the relations of the quadrate with such an amphibian as "*Loxomma*," a conclusion that I have verified by a personal examination of the Munich material.

The single temporal element in *Pariasaurus* is articulated with the outer edge of the quadrate and sends a process inward along its upper border, which in No. 49426 seems definitely to meet the posterior ramus of the pterygoid. Their relations are utterly different from those held by the upper two temporal bones in *Stegocephalia* and *Seymouria*, whilst they are very easily derived from those of the lower temporal element of these more primitive types by the reduction of the part of the squamosal which formerly covered the posterior surface of the quadrate.

It thus seems that we are justified in identifying the temporal element of *Pariasaurus* with the lower and outermost of the three of primitive *Cotylosaurs*.

This element is, I believe, the mammalian squamosal, a thesis which will be discussed in connection with the *Deinocephalian* skull.

One curious feature of the *Pariasaurus* squamosal, the projection of a flange of that bone behind the quadrate, is probably to be accounted for by supposing that the bone formerly finished at the quadrate, leaving a very large otic notch which was subsequently reduced to its actual minute dimensions by the production of the flange.

Systematic position and Relationship of Pariasaurus.

The first author who treated of the systematic position of *Pariasaurus* with the use of adequate material was H. G. Seeley in 1888. In that paper he reached the conclusion, very novel for its time, that *Pariasaurus* resembled *Amphibia*, *Reptilia*, and *Mammals* in different characters, and was intermediate between them. Although much of the evidence on which this conclusion was based has been shown to be incorrect, the conclusion itself remains remarkably near the truth.

All recent authors agree in placing *Pariasaurus* amongst the *Cotylosauria*, an attribution the meaning of which will now be discussed.

The Group *Cotylosauria* was founded originally on an erroneous interpretation of the character of *Diadectes*, which is the typical form of the group. As extended and used by all modern authors

it includes such types as *Seymouria*, *Diadectes*, *Procolophon*, *Captorhinus*, *Pariotichus* and *Pantylus*. These reptiles are extraordinarily different in many features, and those in which they agree are essentially primitive characters which they share with Temnospondylous Stegocephalia.

The group is in fact only held together by the following character, which separates it from other reptiles:—

The skull is completely roofed in the temporal region; every other feature in the skeleton can be matched in some or other early reptile.

Cotylosaurs are distinguished from the Temnospondylous Amphibia solely by the facts, that the intercentra are reduced and the neural arches are expanded and thickened and the zygapophysial articulating faces placed horizontally, and by the presence of only two bones in the proximal row of the tarsus (I believe this feature does occur in some small Stegocephalia which, as shown by the fusion of the hæmal arches to the centra in the caudal region, are quite unconnected with reptilian ancestry).

It is quite certain that the Reptilia, as a whole, must have been derived from a form with a roofed temporal region, for all known Carboniferous amphibia have this feature, and so also have all Palæozoic bony fish. Therefore this character, which alone separates and holds together the Cotylosaurs, is merely a primitive one. Whether all reptiles are derived from a cotylosaurian ancestor is not so certain; it is conceivable, though I do not regard it as at all probable, that some of them might be derived from amphibian types which had developed temporal vacuities. The fact that quite a number of early reptiles shew traces of the broad neural arches and horizontally placed zygapophysial facettes, which are on the whole the most characteristic of all the structures of the post cranial skeleton of Cotylosaurs, suggests strongly that these types at any rate, and of course their allies, have been derived from reptiles which, if we knew them, would be unhesitatingly called Cotylosaurs.

Seymouria stands apart from all other Cotylosaurs in the extraordinarily Stegocephalian appearance of its skull, its resemblance that is to the skulls of the majority of Temnospondyls and Stereospondyls, for it does not resemble more closely than those of other Cotylosaurs the skulls of the smaller Stegocephalia, the Branchiosaurs and "Microsaurs."

This resemblance depends on:—

1st. The shape of the skull.

2nd. The narrow otic notch placed high up so that the tabularia are fairly near to the middle line.

3rd. The fact that the quadrate slopes backwards so that its lower end lies far behind the upper.

4th. The upward direction of the opisthotics.

These four characters are really all connected, the presence of any one almost implies the others.

I do not think there can be much doubt that in these features

Seymouria has retained the structure of the most primitive reptiles.

If we consider later large Amphibia, we find that there is a tendency, which is repeatedly expressed, to replace the inclined quadrate by a vertical one; this is the case for example in *Batrachosuchus*, *Brachyops*, *Plagiosternum*, etc.

Exactly the same change takes place in Cotylosaurs. There are two extreme ways in which an inclined quadrate can be converted into a vertical one, either (a) the lower end is kept fixed and the upper end swung backwards, or (b) the reverse takes place.

The process (a) will result in a complete obliteration of the otic notch, and the squamosal will be brought into line with the tabular on the extreme back of the skull; this is probably the type of change which has produced such types as *Labidosaurus* and *Captorhinus*. In such types the tabulare, if it be present, being firmly fixed between the squamosal and the postparietal, does not really require any additional support, and the outer end of the opisthotic is free to wander down to the region of the quadrate condyle to render support to that bone.

The process (b) results in the retention of the otic notch and in fact in its exaggeration. To it we owe types like *Diadectes* and *Procolophon*, with an enormous otic notch overhung at the top by the squamosal and tabulare, and with the whole of the quadrate in advance of the basioccipital condyle. In these types the opisthotic is far removed from the quadrate and has no possible opportunity of supporting it.

From such a type *Pariasaurus* was undoubtedly derived by the subsequent obliteration of the otic notch, by the development of secondary plates from the squamosal and quadratojugal behind the quadrate. Even in these types the opisthotics have a tendency to rotate downwards, probably to extend the area for the attachment of neck muscles; in doing so they take the tabulars which are attached to their outer ends with them.

Another important type of change has been pointed out by v. Huene. This is that the postparietals and tabulares, which in Stegocephalia and *Seymouria* are bones on the upper surface of the skull, tend in later Cotylosaurs to be reduced to thin films placed vertically on the back of the skull. This change is a very important one.

We may now consider the relationship of *Pariasaurus* to such other Cotylosaurs as are sufficiently well known to make a comparison of any value.

Seymouria baylوريensis differs in the following characters, which are primitive ones:—

- (1) The shape of the skull.
- (2) The narrow otic notch.
- (3) The inclined quadrate.
- (4) The upwardly directed opisthotic.

- (5) The retention of three temporal bones.
 - (6) The primitive palate, identical in all important features with that of the primitive embolomorous Stegocephalia.
 - (7) The primitive humerus with a huge entepicondyle.
 - [(8) The single sacral rib. From the conditions found in carboniferous embolomorous Stegocephalia I am inclined to doubt if this is really primitive.]
 - (9) The ordinary pelvis.
 - (10) The expanded ribs.
- And in the following specialisations:—
- (11) The loss of the cleithrum.
 - (12) The loss of the posterior coracoidal element.

Diadectes and its allies differ considerably less from *Pariasaurus* than does *Seymouria* in most features, whilst they possess many advanced characters in which they differ from it more than does the latter type.

The only primitive features in which *Diadectes* differs from *Pariasaurus* are:

- 1. The retention of a supratemporal.
- 2. The expanded ribs.
- 3. The large entepicondyle of the humerus.
- 4. The simple pelvis.

Diadectes differs in the following advanced characters:—

- 5. The posttemporal vacuities are closed.
- 6. The postparietals and tabulares are placed more on the back of the skull than on the dorsal surface, so that they overlap the supraoccipital.
- 7. The common development of hypopophysial articulations.

The two types agree in many characters, for example:—

- 1. The concave basioccipital condyle.
- 2. The fact that the vertically placed quadrate is far forward.
- 3. The fact that the anterior part of the brain-case is surrounded by bone, which in *Pariasaurus* is a single sphenethmoid whilst in *Diadectes* it is said to be a paired "alisphenoid," but there is no doubt that the conditions are essentially similar.

These characters are all primitive ones.

There is in fact no doubt whatever that *Diadectes* and *Pariasaurus* are not in the least closely allied, but represent two lines differing fundamentally in the evolution of the brain-case, which in *Pariasaurus* is depressed and articulates with the roof of the skull only by a supraoccipital which is a solid narrow pillar separating large posttemporal vacuities and articulating with the lower surface of the parietal and postparietal; whilst in *Diadectes* the brain-cavity is high and the supraoccipital is expanded into a wide plate which is overlapped by the downturned postparietals.

It is difficult to compare *Pariasaurus* with *Limniscelis*, for no

description of the occiput has yet been published, and I am not sure that I understand rightly the figure of that region.

Apparently, however, that type resembles *Diadectes* in the closure of its posttemporal fossæ by the tabulares extending downwards to meet the whole of the opisthotic and supraoccipital border, and the supraoccipital is spread out into a wide plate. If this is so, the type can have no more than the most remote relationship to *Pariasaurus*.

Labidosaurus and *Captorhinus* resemble *Pariasaurus* in the loss of the temporal bones except the squamosal, and in the preservation of the posttemporal fossæ. They differ, however, completely in the primary loss of the otic notch, the bending down of the opisthotics till their outer ends are near the condyles of the quadrates, and in the placing of the postparietals vertically on the back of the skull. They also seem to differ in the loss of the sphenethmoid or any ossification of that character.

In the postcranial skeleton they differ in having lost the cleithrum, and in their curious humerus, which is quite different from that of *Pariasaurus*; and also in the presence of abdominal ribs and in the retention of an unspecialised pelvis.

Too little is known of *Pantylus* to make a comparison of any value.

I postpone any comparison with *Procolophon* until I describe that form.

In the foregoing comparisons I have laid great stress on the characters of the occiput and brain-case generally. I have done so because a study of this region in material representing nearly all the large groups of Reptiles and large Stegocephalia has convinced me that it is really one of the most important regions of the animal from a taxonomic standpoint.

It is in direct relation with the brain, and the general trend of palæontological thought seems to be tending to the view that the important part of evolution takes place in the brain, other characters following after. In addition this region houses the ear, and is far more removed from the action of external conditions than are such features as the palate and the temporal region. It is well known that in mammals the otic region and the base of the skull are of great importance in determining relationships for precisely this reason.

Since the time of Seeley most authors have felt that *Pariasaurus* might have some connection with Therapsid ancestry. This view was founded mainly on the extraordinarily mammalian appearance of the pelvis, where, although there is no pubo-ischiac

vacuity, the thrusting back of the acetabulum till it lies entirely behind the sacrum and the size of the latter, make the whole very mammalian; another feature in which this type resembles the Therapsids is the reduction of the phalangeal formula.

It is therefore necessary to compare the skull of *Pariasaurus* with that of a Therapsid; before doing so it will be convenient to discuss what are really the essential features of that great group.

The group Therapsida was founded by Broom to include all the South African reptiles which are admittedly closely related, *i. e.* the Anomodontia, "Cynodontia," "Therocephalia," Deinocephalia, and Dromasauria. It will be most convenient to see what characters are really common to all these types, then to discuss which of these characters are common also to other great groups of early reptiles which are admittedly not very closely related, and which features may be regarded merely as a primitive inheritance, and so to discover by elimination what characters are really diagnostic of the group. I have been able to examine satisfactory material of all the orders, that of the Dromasauria, which I only know through the kindness of Dr. Broom, being the least satisfactory in details of cranial structure.

The Deinocephalia are large reptiles of very massive structure. Skull with one temporal vacuity surrounded by the squamosal and postorbital (or by the same two bones with the parietal in addition?). No temporal bone except the squamosal. Temporal region short and pineal foramen far back. The occiput composed of a plate with very small laterally placed posttemporal fossæ, the supraoccipital overlapped by the vertically placed interparietal and tabulares, which are entirely on the back of the skull, and the latter of which reach down outside the posttemporal fossæ to the ends of the opisthotics. Brain-cavity very high. [Opening to inner ear placed low down?] Stapes in contact with the quadrate. Quadrate large, partially overlapped behind by the squamosal; a quadratojugal present. Palate not well known.

Septomaxillary present on the face; lachrymal not reaching septomaxillary.

Lower jaw with flat angular, with a notch on the lower border.

No intercentra behind the atlas; ribs double-headed throughout the presacral part of the column; four sacral vertebrae?

Two coracoidal elements, the anterior not contributing to the glenoid cavity.

Pelvis with a short vertically placed ilium; pubis and ischia meeting each other to form a plate-like pelvis.

Humerus of an expanded and twisted type, with an entepicondylar foramen.

[This description is founded on the British Museum material of *Tapinocephalus* and closely allied genera.]

ANOMODONTIA. (*Dicynodon* etc.)

The Anomodonts are small to large reptiles of semi-crawling gait and herbivorous diet. There is one temporal vacuity surrounded by the postorbital and squamosal, or the same bones with the jugal in addition. No temporal bone except the squamosal. Temporal region short, pineal foramen not very far back, a pre-parietal present.

Occiput composed of a plate with small laterally placed post-temporal vacuities. Supraoccipital overlapped by the vertically placed interparietal [and tabulares when present.] Brain-cavity very high. Opening to inner ear placed very low down. Stapes in contact with the quadrate. Quadrate small, almost completely overlapped behind by the large triradiate squamosal. Quadrato-jugal present, but almost invariably fused with the quadrate. Palate with large pterygoids, meeting below the basisphenoid, then separating so as to leave a large interpterygoid vacuity, reaching forward to the prevomers. Prevomers—fused, separating the posterior nares, a rudimentary secondary palate formed by maxillæ and palatines. Transverse present or not. Parasphenoid a long, thin vertically placed plate forming a rostrum to the basisphenoid and extending forward over the interpterygoid vacuity to the prevomers (? in all types). Teeth on the maxilla only, sometimes absent. Septomaxillary always present, sometimes in the nostril, sometimes on the face; lachrymal meeting or not meeting the septomaxillary. Lower jaw with flat angular, with a deep notch overlung by a reflected lamina. 25–28 presacral vertebræ; no intercentra behind the atlas. Ribs double-headed in front, single-headed behind. Sacrum of four to seven vertebræ. Tail short. In shoulder-girdle—scapula with strong acromion, two coracoidal elements, the anterior excluded from the glenoid cavity. Clavicles and broad flat interclavicle always, cleithrum sometimes present. Humerus short, broad, twisted, with an entepi- and sometimes ectepicondylar foramina. Carpus with two centralia and five distal carpals, sometimes unossified; formula of phalanges 2, 3, 3, 3, 3. Pelvis with a large ilium, small pubis and ischia, with a pubo-ischiadic vacuity, sometimes no symphysis between the two halves. Femur long and comparatively slender; two proximal and four distal tarsals and one centrale. Five digits in pes, formula 2, 3, 3, 3, 3 usually, sometimes with additional phalanges in 3rd and 4th toes.

It will be convenient to treat the “Therocephalia” and “Cynodontia” together, as the two groups in a wide sense stand in the relation of parent and child.

Small to large reptiles of carnivorous habit, semi-crawling to thoroughly cursorial.

Skull with a single temporal vacuity (? traces of another in *Cynognathus*) bounded by the postorbital and squamosal, sometimes with the parietal and jugal in addition. Only a squamosal of the temporal elements. Temporal region short to fairly long.

Pineal foramen far back to far forward. Occiput composed of a plate with small laterally placed post-temporal vacuities; supra-occipital overlapped by the vertically placed interparietals and tabulares, which reach down to the opisthotics. Brain-case very high; opening to inner ear placed very low down. Stapes in contact with quadrate. Quadrate small to very small, almost completely overlapped behind by the squamosal. Quadratojugal usually absent, but sometimes represented by a rudiment. Palate very variable, showing the gradual development of a mammalian type from an almost typical primitive reptilian palate. (It is completely known in very few types.)

Septomaxillary always present on the face or in the nostril.

Lower jaw with flat angular, with a deep notch overlaid by a reflected lamina, which becomes rudimentary in later forms.

About 28 presacral vertebræ, three or four sacrals. Inter-centra in the front part of the column. Ribs double-headed in front, single-headed behind.

Scapula with or without an acromion. Two coracoidal elements, the anterior excluded from the glenoid cavity, clavicles and broad flat interclavicle always present, cleithrum present or absent.

Humerus short and expanded to long and very slender, always twisted; entepi- and ectepicondylar foramina always? present.

Carpus (only few types) with two centralia and five distalia. Five digits; formula 2, 3, 4, 5, 4, later reduced to 2, 3, 3, 3, 3.

Pelvis without a pubo-ischiadic vacuity in early types, with one in later forms.

DROMASAUROIDEA. (*Galecheirus*, etc.)

Small arboreal reptiles with long slender limbs.

Skull short, with one temporal vacuity bounded by the squamosal and postorbital and? jugal. Pineal foramen far back. Preparietal present(?). Occiput very badly known but apparently very similar to that of a Deinocephalian. Ear and brain-cavity unknown. Quadrate unknown. Quadratojugal probably absent. Palate unknown. Lower jaw with large dentary and apparently flat notched angular.

Tail very long.

Scapula without acromion, two large coracoidal elements. Clavicles and broad flat interclavicle.

Humerus long, very slender, and twisted.

Carpus with two centralia; digital formula 2, 3, 3, 3, 3.

Pelvis with small upright ilium and large plate-like pubis and ischium.

Femur very long and slender. Tarsus with two proximal and four distal tarsals and one centrale. Digital formula 2, 3, 3, 3, 3.

Comparison of these short descriptions will show that the only features which are of any importance* in which the five great groups agree are :—

1. There is one lateral temporal vacuity.
[The material suggests that in primitive types this was bounded by the postorbital and squamosal alone, and is hence not homologous with either of those of *Sphenodon*.]
2. There is only a squamosal in the temporal region.
3. The occiput is plate-like, the supraoccipital being broadened to a wide flat plate, which separates very widely the small posttemporal vacuities.
4. There is a single interparietal formed by a fused pair of postparietals, which, with the tabularia which are usually present, is placed entirely on the back of the skull and overlaps the supraoccipital.
5. The brain-cavity is very high.
6. The opening from the brain-cavity to the ear is very low down.
7. The stapes articulates with the quadrate.
8. The angular is flat and notched.
9. The interclavicle is always flat and wide, not T-shaped.
10. There are two coracoidal elements.
11. The anterior coracoidal element does not contribute to the glenoid cavity,
12. There are always two centralia and five distal carpals when the carpus is well ossified.
13. There are always two proximal and four distal tarsals and one centrale when the tarsus is well ossified.

Of these characters, which include all common to all South-African Therapsids that are likely to be of taxonomic importance, Nos. 9 & 10 are merely primitive features, and so in all probability are 12 & 13.

In fact, the characteristic features of the Therapsids, which show the real individuality of the group, are those numbered 1–8. Numbers 3–6 are really so connected as to be essentially one character, and with the condition of the angular and stapes are the only features which we could hope to recognise in a *Cotylosaurian* ancestor.

It will be found that all these characters, except the exclusion of the anterior coracoidal element from the glenoid cavity, and the occasional presence of a vestigial supratemporal in the temporal region, occur in the various American types which have been included in the *Pelycosauria*.

Dimetrodon, for instance, has a single temporal vacuity, its

* They, of course, agree in such characters as the presence of parietals, prefrontals, lacrymals, etc.

occiput is plate-like with a wide supraoccipital separating the posttemporal fossæ. Any bones which could be postparietals or tabulares are on the posterior surface overlapping the supraoccipital, the brain-cavity is very high, and the ear, as shown extremely well by the "brain-cast" figured by Case, is very low in the skull.

The angular is flat and notched; there are two coracoidal elements, the interclavicle is flat and wide and not T-shaped, and the carpus and tarsus are of thoroughly Therapsid type. In fact, every character that is found in all South-African Therapsids is also present in *Dimetrodon*, which must hence be included in the same group. [It is, however, much more primitive than any South-African type in many features.]

With *Dimetrodon*, *Edaphosaurus* must go to the Therapsids, for it also has the characteristic occiput and angular.

Varanosaurus, as shown by the magnificent type-specimen of *V. acutirostris* in Munich, has an occiput of the same type, although of course it is very incompletely known. Unfortunately the angular of this type is completely unknown; the form has, however, the two coracoidal elements, shown extraordinarily clearly in the Munich specimen, a flat and not T-shaped interclavicle, and, as shown by Williston's excellent description, the feet only differ by lack of ossification of centralia. It can, I think, also be regarded as a Therapsid.

When one comes to *Ophiacodon* the problem becomes much more difficult. The whole of the post-cranial skeleton of that type, as described by Williston and Case, seems to be essentially identical with *Varanosaurus*, but the extraordinary skull with two temporal vacuities is apparently very different. It is exceedingly unfortunate that no description of the occiput or lower jaw is possible, and, in my opinion, in the absence of that knowledge, we are not justified in discussing the position of *Ophiacodon* amongst primitive Reptilia.

The foregoing discussion will, I hope, have made clear what, in my opinion, are the really important characters of the Therapsids; it remains only to examine *Pariasaurus* in the light of them.

It shares with the Therapsids the possession of two coracoidal elements and a single squamosal bone. The occiput is not in the least plate-like, the postparietals and tabulares are quite on the upper surface of the skull, the brain-cavity is long and low, the opening from the brain-cavity to the inner ear is high on the side-wall of the brain-cavity, the angular is boat-shaped, and the internal mandibular vacuity, which, by its excessive enlargement, gives rise to the flat Therapsid angular, is extremely small; the interclavicle is T-shaped and narrow; there are no centralia on the carpus or tarsus, and the proximal tarsals are fused.

It is thus certain that so far from being at all closely related to the Therapsids, *Pariasaurus* represents an extremely different

branch of the early reptile stock, any resemblance which it bears to them being simply due to convergence.

I wish to express my thanks to Drs. A. Smith Woodward and C. W. Andrews for much help during my work at the Natural History Museum, and to Herren Prof. F. Broili in München and Prof. F. v. Huene in Tübingen, who allowed me to work over the fine series of Texas "Permian" vertebrates in the museums of their respective Universities. Finally, I have to thank the Percy Sladen Trustees, who assisted me to visit South Africa, and especially G. Gordon, Esq., the owner of Hottentots Rivier, to whose hospitality and interest I owe the specimen of *Pariasaurus* which forms the basis of this paper, and Mr. R. Hall of the British Museum, to whose skill and care as a preparator our detailed knowledge of *Pariasaurus* is very largely due.

11. Report on the Deaths which occurred in the Zoological Gardens during 1913, together with a list of the Blood-Parasites found during the Year. By H. G. PLIMMER, F.R.S., F.Z.S., Pathologist to the Society.

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INDEX.		Page
Pathology		181
Parasitic Protozoa		188
Parasitic Nematodes		187

On January 1st, 1913, there were 826 mammals, 2162 birds, and 486 reptiles in the Zoological Gardens; and during the year 446 mammals, 1356 birds, and 683 reptiles were admitted, making a total for the year of 1272 mammals, 3518 birds, and 1169 reptiles.

During 1913, 356 mammals, 857 birds, and 467 reptiles have died: that is, a percentage of 27·9 for mammals, 24·3 for birds, and 39·4 for reptiles.

Out of the total deaths for the year, 1680 in all, 723 occurred in animals which had not been six months in the Gardens: that is nearly half the total number. It has been found that after six months' residence in the Gardens, the death-rate falls rapidly; so that it is assumed that by that time the new animals have got over their journeys, or have died from any diseases they may have brought with them, or have got quite used to their new environment. Of these 723 animals, 141 were mammals, 277 were birds, and 305 were reptiles; and if these be deducted from their respective totals the death-rate will appear as 16·9 per cent. for mammals, 16·4 per cent. for birds, and 13·8 per cent. for reptiles.

The following Tables show the facts which have been ascertained, in outline. Table I. summarizes the actual causes of death in the three groups specified. Under Reptiles are included Amphibia and a few Fishes.

TABLE I.—Analysis of the Causes of Death.

Diseases.	Mammals.	Birds.	Reptiles.	Reference to Notes following.
1. <i>Microbic or Parasitic Diseases.</i>				1
Tuberculosis	31	104	6	2
Mycosis	8	75	1	3
Pneumonia	34	89	138	4
Septicæmia	1	...	...	
Abscess	1	...	...	
Pericarditis	1	1	...	
Peritonitis	5	1	...	
Empyema	6	...	...	
Stomatitis	...	...	1	
Pylephlebitis	2	...	...	5
Hydatids	1	...	...	
Worms	...	...	2	

TABLE I.—Analysis of the Causes of Death (*continued*).

Disease.	Mammals.	Birds.	Reptiles.	Reference to Notes following.
<i>2. Diseases of Respiratory Organs.</i>				
Tracheitis	...	1	...	} 6
Broncho-pneumonia	25	...	...	
Bronchitis	6	...	...	
Congestion of lungs	14	98	13	
Atelectasis	1	...	...	
<i>3. Diseases of the Heart.</i>				
Pericarditis	...	3	...	7
Degeneration of heart-muscle ..	1	1	...	
<i>4. Diseases of the Liver.</i>				
Hepatitis	...	3	...	
Fatty degeneration	...	4	...	
Cirrhosis	...	1	...	
<i>5. Diseases of the Alimentary Tract.</i>				
Gastritis	3	2	1	8
Gastric ulceration	4	...	2	
Gastro-enteritis	7	...	9	} 9
Euteritis	33	148	15	
Intestinal obstruction	2	2	...	10
Intussusception	3	...	...	
Strangulated intestine	1	...	...	
Perforation of intestine	1	...	...	
Prolapse of rectum (sloughing) ..	1	...	...	
Perforation of proventriculus ...	...	1	...	11
<i>6. Diseases of Urinary and Generative Organs.</i>				
Nephritis	90	135	6	12
Cystic kidneys	...	...	1	13
Stone	1	...	...	14
Inflamed oviduct	...	6	...	
Retained placenta	1	...	...	
<i>7. Various.</i>				
Sarcoma	4	1	...	15
Myelitis	1	...	...	
Injuries discovered <i>post-mortem</i> }	7	9	1	

Besides those tabulated above,

44 mammals, 127 birds, 4 reptiles, were killed by order or by companions,

3 „ 11 „ 178 „ died from malnutrition or starvation,

8 „ 36 „ 85 „ were too decomposed for examination,

these completing the total.

In Table I. a classification is made of those diseases which actually caused death, but in most cases the animals were suffering from other diseases as well. Table II. summarizes those other

diseases from which the animals were suffering; and if this Table be taken in conjunction with Table I., a much more accurate estimate of the amount of disease in the Gardens will be arrived at.

TABLE II.—Other Diseases found in the animals tabulated in Table I.

Diseases.	Mammals.	Birds.	Reptiles.	Reference to Notes following.
Tuberculosis	3	11	...	16 17 18 19
Mycosis	4	4	2	
Pneumonia	4	3	7	
Pericarditis	2	...	...	
Peritonitis	10	...	...	
Abscess	4	...	3	
Empyema	2	...	...	
Septicæmia	1	...	...	
Stomatitis	...	...	7	
Malaria	...	18	1	
Filaria	10	28	...	
Hæmogregarines	...	...	35	
Trypanosomes	...	6	...	
Worms	...	5	9	
Hydatids	4	...	...	
Sarcocystis	1	...	...	20
Leucocytozoa	...	3	...	21
Pyorrhœa	2	...	...	22
Bronchitis	9	1	...	
Broncho-pneumonia	4	...	...	
Congestion of lungs	24	114	9	
Edema of lungs	1	84	10	
Emphysema	2	...	...	
Hydrothorax	2	...	...	
Pleuritis	1	...	...	
Pericarditis	...	10	...	
Fatty heart	...	2	1	
Dilated heart	4	2	...	
Atheroma	5	6	...	
Hepatitis	1	6	2	
Cirrhosis of liver	2	5	...	
Fatty liver	16	70	9	
Gastritis	2	1	...	
Gastric ulceration	14	...	...	
Gastro-enteritis	2	...	2	
Intussusception	1	...	...	
Intestinal obstruction	...	1	1	
Enteritis	22	84	23	
Nephritis	63	70	5	
Cystic kidneys	1	...	...	
Cystitis	5	...	...	
Inflamed oviduct	...	1	...	
Rickets	7	1	...	
Malnutrition	4	7	5	
Ascites	1	2	1	
Injuries	5	9	...	

Table III. shows, in still further detail, the distribution of diseases amongst the various orders of mammals.

TABLE III.—The Distribution of Diseases causing Death amongst the principal Orders of Mammals.

Diseases.	Primates.	Carnivora.	Rodentia.	Ungulata.	Edentata & Insectivora.	Marsupialia.
Tuberculosis	16	5	9	1	...	...
Mycosis	...	...	1	1	...	6
Pneumonia	10	6	13	2	...	3
Abscess	...	1	...	...	...	...
Pylephlebitis	...	...	...	2	...	...
Empyema	1	2	1	1	...	1
Pericarditis	...	...	...	1	...	...
Peritonitis	...	2	1	1	...	1
Hydatids	1	...	...	...	...	...
Septicæmia	...	1	...	...	...	...
Bronchitis	3	...	1	1	1	...
Broncho-pneumonia	8	6	3	6	1	1
Congestion of lungs	6	...	5	2	1	...
Atelectasis	...	...	...	1	...	...
Fatty heart	...	...	...	...	...	1
Gastritis	...	...	...	2	1	...
Gastro-enteritis	2	1	3	...	...	1
Intestinal obstruction	...	2	...	...	...	...
Perforation of intestine	...	...	...	1	...	...
Gastric ulceration	2	...	2	...	...	...
Strangulation of intestine	...	1	...	...	...	...
Sloughing intestine	...	1	...	...	...	...
Intussusception	...	2	...	...	...	1
Enteritis	9	9	7	6	2	...
Nephritis	20	31	13	12	3	10
Stone	...	...	...	1	...	...
Sarcoma	1	1	2	...	...	...
Myelitis	...	1	...	...	...	...

Notes on the foregoing Tables.

1. The total incidence of infectious diseases in the Gardens is about 7 per cent. for mammals and birds and 12 per cent. for reptiles.

2. There has been an increase in the deaths from tubercle amongst the mammals and birds. In the former it was due to an epidemic which broke out in the old Insect House in 1912: 15 of the 31 cases in mammals came from this House. 13 of the 31 mammals had not been in the Gardens for six months, and 4 of them had been pet animals. The most interesting case was that of an Ibex under one month old, which had tubercle in one lung and in the thymus: there was scarcely any healthy tissue

left in the latter organ. In the case of a Bear the disease was of human type. Most of the cases in birds would appear to have been acquired in the Gardens, as only 22 of them had been less than six months in the Gardens. In 61 of the birds it was acute, and was a general infection: in 11 it was of bovine type. 4 of the reptiles, which show a considerable decrease, were tortoises.

3. All the mould-diseases have been grouped under mycosis. Of the 8 mammals, 6 were Kangaroos and the disease was of the same type as that previously described, 1 was in a Gazelle, of same type, and the other was a mycotic disease of the intestine in a Beaver, in which the mould was of a different variety. The number of deaths from mycosis in birds is still very high, and constitutes 8·7 per cent. of the deaths in birds. Some young Pheasants died from mycosis at the age of 14, 17, and 20 days, with mycotic growth in all the organs and filling the body-cavities.

4. There has been a slight decrease in the incidence of pneumonia in mammals and birds, and a slight increase in reptiles. In 5 of the latter it was due to irritation caused by worm eggs; the rest were pneumococcal and constitute about 30 per cent. of the number of deaths in reptiles.

5. In umbilical veins of recently born Buffalo and Gnu.

6. There has been a general decrease of these diseases of the respiratory organs: they are largely dependent on weather.

7. These cases of pericarditis in birds were not due to infection, but to a deposit of crystals in the pericardium associated with chronic kidney disease.

8. The two birds were Penguins, in which over-distension with fish was the cause.

9. In 6 of the mammals, 14 of the birds, and 3 of the reptiles the inflammation was caused by parasites (worms and coccidia). In 1 of the mammals and 7 of the birds the cause was a traumatic one (sand, hay, etc.). In 7 of the mammals and 65 of the birds it was hæmorrhagic, and probably of bacterial origin. The remainder of the cases were apparently due to the quantity or quality of the food not being suitable to the animal.

10. Two of these had intussusceptions were in Genets.

11. In a Plover from wire.

12. There has been a slight increase in the number of cases of nephritis. Under this are grouped the acute and chronic cases, many of the latter being the result of old age. 14 of the cases in mammals were acute, and 32 of the cases in birds: the rest were of varying degrees of chronicity. Many of the mammals and birds had associated lung lesions, which would seem to indicate that climatic conditions and exposure may be answerable for these cases.

13. In a Terrapin in which both kidneys were converted into multiple cysts.

14. In an Antelope in which a stone impacted in the urethra had produced a ruptured bladder.

15. Two of these were lympho-sarcomata of the abdominal glands in two sheep, mother and son, from the same house. The others were an angiosarcoma of liver in a Coypu rat, a sarcoma of the scalp in a Cercopithecus, and an adeno-sarcoma in a Rail.

16. The diseases grouped under the term malaria were due in 12 instances to *Hæmoproteus danilewskyi* and in 6 instances to *Plasmodium præcox*.

16, 17, 18, 19, 21. See the section on blood-parasites below.

20. This was a very considerable infection of the muscles of a Langur, which was not visible to the naked eye.

22. There has been a considerable decrease in the number of rickety mammals.

In comparing the deaths recorded in this Report with those of the five preceding years, there are two points which seem to be in continual prominence, and which must therefore be of practical importance. The one is the fact that a large number of animals—in the large sense—nearly half of the total number, have died within six months from their admission to the Gardens, the majority of these dying within three months. Of these, a large number die of microbic or parasitic diseases.

The other fact is that a very large percentage of animals have died from inflammatory conditions of the alimentary tract which cannot be attributed to mechanical or microbic causes, and which are apparently due to some defect in their food, the quality or quantity or both not being suitable to the animal.

From a consideration of these facts, it would seem possible that the point first mentioned could be dealt with practically by a proper and effective quarantine, which would prevent the introduction into the Gardens of new infections, or of those already existing there, in a condition of increased virulence.

As regards the cases next mentioned, a careful consideration by experts of the feeding of the animals throughout the Gardens, would enable reasonable and physiological alterations to be made, and probably would reduce effectively the death-rate from this cause.

BLOOD-PARASITES.

During the year the blood of every animal which died has been examined, with the result that parasites have been found in 138; in 60 species for the first time.

They have been distributed as follows:—

Filarie. In 5 mammals; found in 3 species for the first time.

28 birds; in 20 species for the first time.

5 reptiles; in 1 species for the first time.

Trypanosomes. In 8 birds; in 5 species for the first time.

2 reptiles.

<i>Malaria.</i>	{	<i>Hæmoproteus danilewskyi.</i>	In 14 birds; in 7 species for the first time.
		<i>Plasmodium præcox.</i>	In 6 birds; in all for the first time.
		<i>Hæmocystidium.</i>	In 1 reptile.
<i>Leucocytozoa.</i> In 4 birds; in 2 species for the first time.			
<i>Hæmogregarines.</i> In 64 reptiles; in 14 species for the first time.			
<i>Intestinal organisms of</i>		{	In 1 reptile for the first time.
<i>Hexamitus type.</i>			

The following Tables show the occurrence of the blood-parasites in detail:—

Embryo Filarie found in the blood of Mammals.

	HABITAT.	TYPE OF FILARIA.
2 Lion Marmosets (<i>Leontocebus rosalia</i>).	Brazil.	Long.
<i>Found in the following for the first time:</i>		
Short-tailed Wallaby (<i>Macropus brachyurus</i>).	Australia.	Long, thick, very pointed.
Rock Wallaby (<i>Petrogale penicillata</i>)...	Australia.	Long, thick.
Martin's Cercopitheque (<i>Cercopithecus martini</i>).	W. Africa.	Long.

Embryo Filarie found in the blood of Birds.

White-throated Jay Thrush (<i>Garrulax albicularis</i>).	India.	Short, thick, no vacuole.
Lanceolated Jay (<i>Garrulus lanceolatus</i>).	India.	Short, pointed.
Brazilian Hangnest (<i>Icterus jamaicæi</i>)...	Brazil.	Long, no capsule.
Mexican Jay (<i>Xanthura læuosus</i>)	Mexico.	Long, pointed.
Wood Thrush (<i>Turdus mustelinus</i>)	N. America.	Short, pointed.

Found in the following for the first time:

Albert Towhee (<i>Pipilo alberti</i>)	N. America.	Short, thick.
Rose Finch (<i>Carpodacus erythrinus</i>) ...	India.	Long.
Black Bullfinch (<i>Melanopyrrha nigra</i>) .	Cuba.	Long, pointed.
Black Francolin (<i>Francolinus vulgaris</i>).	India.	Long.
Mexican Rose-Finch (<i>Carpodacus mexicanus</i>).	Mexico.	Long.
Black-shouldered Tanager (<i>Calliste melanonota</i>).	Brazil.	Short, thick.
Mahali Weaver-bird (<i>Plocepasser mahali</i>).	S. Africa.	Short, pointed.
Nuthatch (<i>Sitta cinnamomeiventris</i>) ...	India.	Long, thick.
Chestnut-bellied Nuthatch (<i>Sitta castaneiventris</i>).	India.	Long, pointed.
Pileated Song Sparrow (<i>Zonotrichia pileata</i>).	S. America.	Short.
Cuban Amazon (<i>Chrysotis leucocephala</i>).	Cuba.	Short, thick, pointed.
Red-shouldered Starling (<i>Agelæus phœniceus</i>).	N. America.	Short, pointed.
Sulphury Tyrant (<i>Pitangus sulphuratus</i>).	S. America.	2 kinds; one very long, the other very short and thick.

Great Grey Shrike (<i>Lanius excubitor</i>) ...	Europe.	No capsule, very striated.
Swainson's Blue Jay (<i>Aphelocoma sor- dida</i>).	Mexico.	Short.
Red-billed Hornbill (<i>Lophoceros erythro- rhynchus</i>).	Africa.	Short.
3 Indian Rollers (<i>Coracias indica</i>)	India.	Short.
2 White-headed Starlings (<i>Poliopsar leucocephalus</i>).	China.	Long.
Larger Hill-Mynah (<i>Gracula inter- media</i>).	India.	Short, thick, and pointed.
Malaccan Parrakeet (<i>Palæornis longi- cauda</i>).	Malacca.	Long.

Embryo Filarice found in the blood of Reptiles.

Edible Frog (<i>Rana esculenta</i>)	Europe.	Short, thick.
2 Say's Snakes (<i>Pituophis sayi</i>)	N. America.	Long.

Found in the following for the first time :

2 Warty Chameleons (<i>Chamæleon verru- cosus</i>).	Madagascar.	Short, stout, with thick capsule.
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Trypanosomes found in the blood of Birds.

2 Blue-crowned Hanging Parrakeets (<i>Loriculus galgulus</i>).	Malay.
Little Owl (<i>Athene noctua</i>)	Europe.

Found in the following for the first time :

Goldfinch (<i>Carduelis elegans</i>)	N. Europe.
Shama (<i>Cittocincla macrura</i>)	India.
Tawny Owl (<i>Syrnium aluco</i>)	Europe.
Spotted-sided Finch (<i>Steganopleura gut- tata</i>).	Australia.
Brazilian Hangnest (<i>Icterus jamaicæ</i>) .	Brazil.

These were all of the type of *Trypanosoma avium*.

Trypanosomes found in the blood of Reptiles.

Tree-Frog (<i>Hyla arborea</i>) (blue variety).	S. Europe.
Edible Frog (<i>Rana esculenta</i>)	S. Europe.

These were of the type of *Trypanosoma rotatorium*.

*Intestinal Organism found in the Blood of the following Reptile
for the first time.*

Rough Terrapin (<i>Nicoria punctularia</i>) .	S. America.	Of Hexamitus type.
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Hæmogregarines found in the blood of Reptiles.

3 King-Snakes (<i>Coronella getula</i>)	N. America.	Small, short.
3 Rat-Snakes (<i>Zamenis mucosus</i>)	India.	Medium sized.
Reeves's Terrapin (<i>Damonia reevesi</i>) ...	China.	Small, short.
2 Bushmasters (<i>Lachesis mutus</i>)	Trinidad.	Large, host-cells enlarged and de hæmoglobinised.
3 Cobras (<i>Naia tripudians</i>)	India.	Long.
3 Dark Green Snakes (<i>Zamenis gemon- ensis</i>).	S. Europe.	Small, host-cells enlarged.

Diamond Python (<i>Python spilotes</i>)	Australia.	Large.
Blood-stained Terrapin (<i>Cinosternum cruentatum</i>).	S. America.	Long.
3 Hog-nosed Snakes (<i>Heterodon platyrhinos</i>).	N. America.	Large, host-cells enlarged.
8 Common Boas (<i>Boa constrictor</i>)	S. America.	Large, host-cells enlarged.
Eyed Lizard (<i>Lacerta ocellata</i>)	S. Europe.	Long, host-cells enlarged.
5 Rattlesnakes (<i>Crotalus atrox</i>)	N. America.	Large, host-cells enlarged.
3 Testaceous Snakes (<i>Zamenis flagelliformis</i>).	N. America.	Long, host-cells enlarged and de hæmoglobinised.
3 Indian Pythons (<i>Python molurus</i>)	India.	Medium, cells deformed.
Anaconda (<i>Eunectes narinus</i>)	S. America.	Long, doubled over.
4 Say's Snakes (<i>Pituophis sayi</i>)	N. America.	Long, host-cells enlarged.
Vivaceous Snake (<i>Tarbohis fallax</i>)	S. Europe.	Medium.
Gallot's Lizard (<i>Lacerta galloti</i>)	N. Africa.	Of Karyolysus type.

Found in the following for the first time :

3 Pigmy Rattlesnakes (<i>Sistrurus miliaris</i>).	N. America.	Small.
Spinose Land-Emys (<i>Geoemyda spinosa</i>).	Malay.	Medium.
Helen's Snake (<i>Coluber heleni</i>)	Ceylon.	Small.
Banded Trichogaster (<i>Trichogaster fasciatus</i>).	India.	Short and thick ; of interest, as they are said not to occur in fresh-water fishes.
Bengal Monitor (<i>Varanus bengalensis</i>)...	India.	Large, of ordinary type.
Cape Viper (<i>Causus rhombeatus</i>)	S. Africa.	Of Drepanidium type ; nearly every corpuscle infected.
Four-lined Chicken Snake (<i>Coluber obsoletus</i> , var. <i>quadrivittatus</i>).	N. America.	Large.
2 Emerald Green Tree-Snakes (<i>Gastro-pyxis smaragdina</i>).	Sierra Leone.	Long, doubled over ; host-cells enlarged.
Graham's Snake (<i>Zamenis grahami</i>)	N. America.	Large, host-cells enlarged.
Harlequin Elaps (<i>Elaps fulvius</i>)	N. America.	Large and doubled over.
Long-nosed Crocodile (<i>Crocodilus cataphractus</i>).	N. Nigeria.	Some short and thick, others long and doubled over.
Leopardine Snake (<i>Coluber leopardinus</i>) .	S. Europe.	Small and thin.
Cananina Snake (<i>Phrynonax sulphureus</i>).	Trinidad.	Large, host-cells enlarged.
Sooty Snake (<i>Boodon fuliginosus</i>)	W. Africa.	Large, host-cells enlarged and de hæmoglobinised.

Hæmoproteus danilewskyi found in the blood of Birds.

HABITAT.

2 Blue-crowned Hanging Parrakeets (<i>Loriculus galgulus</i>)	Malay.
Kestrel (<i>Tinnunculus alaudarius</i>)	Europe.
Eagle Owl (<i>Bubo maculosa</i>)	S. Africa.
3 Indian Rollers (<i>Coracias indica</i>)	India.

Found in the following for the first time :

Malayan Peacock-Pheasant (<i>Polyplectrum bicalcaratum</i>)	Malay.
Shama (<i>Cittocincla macrura</i>)	India.
Siskin (<i>Chrysomitris spinus</i>)	N. Europe.
Tawny Owl (<i>Syrnium aluco</i>)	Europe.
Lanceolated Jay (<i>Garrulus lanceolatus</i>)	India.
Sulphury Tyrant (<i>Pitangus sulphuratus</i>)	S. America.
Lesser Kestrel (<i>Tinnunculus cenchris</i>)	S. Europe.

Plasmodium præcox found in the blood of Birds:

<i>Found in the following for the first time:</i>	HABITAT.
Yellow-fronted Barbet (<i>Cyanops flavifrons</i>)	Ceylon.
Mongolian Pheasant (<i>Phasianus mongolicus</i>)	Mongolia.
Goldfinch (<i>Carduelis elegans</i>)	N. Europe.
White-crested Touraou (<i>Turacus corythaix</i>)	S. Africa.
Swainson's Blue Jay (<i>Aphelocoma sordida</i>)	Mexico.
Wood-Thrush (<i>Turdus mustelinus</i>)	N. America.

Leucocytozoa found in the blood of Birds.

2 Little Owls (<i>Athene noctua</i>)	S. Europe.
<i>Found in the following for the first time:</i>	
Chat (<i>Oreicola ferra</i>)	India.
Tawny Owl (<i>Syrnium aluco</i>)	Europe.